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# SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

**A Journal for all SCIENCE AND MATHEMATICS TEACHERS**

**CONTENTS:**

**Objectives of Science Teaching**

**Trigonometry in the High School**

**Individual Instruction in Mathematics**

**Measuring Automobile Performance**

**Testing Results in Chemistry**

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# SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXI NO. 5 MAY, 1931 WHOLE NO. 268

## ATTENTION, JUNIOR HIGH SHOOL TEACHERS.

The coming of the Junior High School has brought about a reorganization of the curriculum in mathematics, and as a result methods of presenting and teaching subject matter have changed. Some of these changes and their results have been recorded by leaders in the pedagogy of mathematics and have proved interesting and beneficial to teachers. However, the time has come when we would like to know through first hand information just how some of the aims, purposes or objectives have been attained, whether or not they have failed of attainment, what methods have been used, what methods have proved superior, and what results have been obtained.

This information must come from the Junior High School teacher who has had actual contact with the above named problems. Therefore the Editor appeals to all Junior High School teachers for any information that they may have at hand. "What are your problems? What methods do you use to solve them? What results have you obtained in trying out materials and methods advocated by leading writers?" The answers to these questions will be of interest to all teachers. Therefore Junior High School teachers are urged to put their results in written form and send them to the mathematics editor or to the Editor-in-Chief. SCHOOL SCIENCE AND MATHEMATICS is interested in the problems of all teachers and is anxious to serve them to the fullest extent.

CHARLES A. STONE,
Laboratory Schools, University of Chicago.

## WITH OUR EDITORS.

What does a teacher do when he is out of the school room? Many people look upon teaching as a soft job—five to seven hours a day with Saturday off. Such an inventory neglects the many *leisure time* contributions made by teachers. Our editors are primarily teachers and their editorial duties are overtime contributions to education. But this is not all. In fact they are editors because they are leaders in education. Here are some examples.

Dr. George W. Myers, Astronomy Editor during this school year has delivered two important lectures on Astronomy and Religion to an audience of college graduates in one of Chicago's great churches. Another lecture to the Chicago Men's Mathematics Club was published in the December issue of this Journal. He is Consulting Adviser of the Research Committee of the Chicago Men's Mathematics Club. He has served as Cooperating Editor for a great array of mathematics textbooks, workbooks, etc., published by Scott, Foresman and Company. These include Standard Service Algebra Work-Book, Teachers' Manual and Course of Study, Revision of Economy Practice Exercises, Test and Practice Pads for Early Arithmetic, Class and Individual Flash Cards for Early Arithmetic, Standard Service Algebra (to appear soon), and Standard Service Junior High School Series in Mathematics (to appear soon).

At Shortridge High School, Indianapolis, Mr. Frank B. Wade has maintained the high standard of his chemistry teaching and as usual has found time to lead chemistry teachers in several other enterprises. This year he is again Chairman of the Indiana Committee on Prize Essay Contest of the American Chemical Society. At the National Meeting of the American Chemical Society last month he presided over the Symposium on Co-operation between Industry and Chemical Education of the Division of Chemical Education. He is the author of a masterly article on "Man Made Gems" soon to appear in the *Journal of Chemical Education*. May we add parenthetically that Mr. Wade's daughter, Miss Lucille, was recently awarded the Rector Fellowship ($1200) in Bio-Chemistry at De Pauw University for graduate study in any major field next year. Miss Wade is the only girl ever given this award in science.

Our Physics Editor, Mr. Homer W. LeSourd, teacher of physics and head of the science department at Milton Academy, is one of the examiners for the College Entrance Examination Board. He is chairman of the science committee for curriculum study under direction of the Secondary Eduation Board. The report of this committee will be published soon. At the Harvard Teachers Association in March he had charge of the conference on the teaching of Secondary school science. During the second semester he is conducting Professor N. Henry Black's course in teaching methods in science in Harvard Graduate School of Education and will teach two courses in the Harvard Summer School.

*General Chemistry for Colleges* is a textbook prepared last year, during leave of absence, by Dr. B. Smith Hopkins, Professor of Inorganic Chemistry in the University of Illinois, and our Research Editor for Chemistry. This book has been unusually successful in colleges giving a strong course in general chemistry, but it is considered heavy for classes taking an abbreviated course. To meet the needs of such classes of college students Dr. Hopkins is planning a briefer edition and will spend his summer recreation period in preparing this book. Dr. Hopkins not only holds the enviable position of being the only American to discover one of the ninety known elements but he has never lost sight of the importance of teaching and continues his work as a teacher both in the class room and through scientific publications.

During the coming Summer Dr. Charles A. Stone, our Mathematics Editor in charge of Junior High School Mathematics, will give courses at De Paul University, Chicago, on "Statistical Methods Applied to Educational Problems" and "Methods of Teaching Mathematics." In addition to his regular work in The University of Chicago High School, Dr. Stone is now preparing a book on Work Units in Algebra which will be published soon by Allyn and Bacon, and is lecturing at many high schools and colleges on the use of the slide rule.

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Before closing up for the Summer vacation turn the calendar to November and mark Friday, 27th, and Saturday, 28th, the dates of the Annual Convention of the Central Association of Science and Mathematics Teachers.

## AIMS, PURPOSES AND METHODS IN HIGH SCHOOL TRIGONOMETRY.*

BY A. B. MCCAIN,
*Washington High School, Milwaukee, Wis.*

The aims and purposes of teaching any particular branch of science or mathematics at the present time may have no connection or very little connection with the history of its development. On the other hand, they may have a very close connection, for the need that is met by that particular branch is apt to be the same or the outgrowth of the need which first brought the subject into existence. Therefore, it seems to be worth while to just glance at the ancient history of Trigonometry.

David Eugene Smith is authority for this bit of history. The subject of Trigonometry was developed to meet two entirely different needs and had two radically different branches in ancient times. If we take the literal meaning of the term, namely, to measure a triangle, the science goes back probably 2000 years B. C. Evidence is found that the trigonometric ratios were recognized and used even as early as that. But the second need brought about a much more important step with respect to Trigonometry. This was in connection with the study of the sphere. This accounts for the fact that Spherical Trigonomerty finally passed the study of plane triangles.

Hipparchus (140 B. C.) computed a table of chords, the first table of trigonemetric functions extant. Due to this and the Mathematics which it involved, he is often spoken of as the father of Trigonometry. It will be noticed that in ancient times the subject was developed on account of its value in making indirect measurements.

Having taken a glance at the history of Trigonometry, let us now look at the subject itself before going to the statement of aims and purposes in teaching it. J. W. A. Young is responsible for the following discussion. "Trigonometry is usually regarded and taught as a separate subject, but when we come to seek its peculiar characteristics, we fail to find a clear-cut central idea which would serve to give the subject its own individuality." In Arithmetic the central idea is the number concept and this gives the subject

*Read before the Mathematics Section of the Central Association of Science and Mathematics Teachers, November 28, 1930.

its excuse for existence. The central idea in Algebra is the generalized number concept and in Geometry, the space concept and its problems.

What is the corresponding idea upon which Trigonometry is built? Is it the trigonometric ratio? No, this is clearly Geometry. Is it the manipulation of formulae? No, this is clearly Algebra. Most of the chapters in Trigonometry are more closely connected with Algebra or Geometry than they are with each other. The subject as treated falls of itself into a number of parts, the order of which, can be varied without doing any particular violence to the subject. From this it seems evident that the teaching of Trigonometry as a separate and distinct subject can not be defended upon the same grounds that the teaching of the other branches of elementary Mathematics can. This does not mean that there is no reason for teaching Trigonometry as a separate subject. There are very good reasons.

Unless the time spent upon Algebra and Geometry were much lengthened, it would be impossible to develop the various ideas of Trigonometry so as to give the student an adequate knowledge and skill for its use in more advanced work in Mathematics or Science. Moreover, the mental age of the pupil at the time he is studying Algebra and Geometry would make it undesirable if not quite impossible for him to attempt to master all parts of Trigonometry even though it is the direct outgrowth of those subjects.

When we consider the aims and purpose of teaching Trigonometry, we are at once confronted with the same question which arises when we consider the teaching of any other branch of Mathematics: Namely, shall we lay the chief emphasis upon the so called practical or upon the theoretical or shall we equally emphasize both? No conclusion can be reached upon this question until we understand what is meant by "practical" and "theoretical" when applied to the content of courses in high school Mathematics. As near as I have been able to determine we mean by practical any part of the subject matter for which the student can see a direct application in something useful outside of school and by theoretical any part of the subject for which he can see no such application. Any such loose definition of terms as this leads at once to the conclusion, which I believe to be

correct, that there is no place in a branch of Mathematics where we can draw a line and say the practical lies on one side while the theoretical is found on the other. Parts which have been considered theoretical have become very practical. I am willing to risk my reputation as a prophet upon the statement that if any of you have treasured up some discovery in Mathematics which you believe to be entirely theoretical, that is with no practical value except for the sake of Mathematics itself, that you may as well turn it loose, for if you do not, somebody else will discover the same thing and inside the next few hundred years at most it will be found to be exceedingly practical and perhaps just the thing some scientist needs for the work he is trying to do.

In thinking of this subject, it occurred to me that it would be very interesting and instructive to have first hand from men who are constantly coming in contact with the product of the high school, their opinion upon this matter based upon their experience. I, therefore, wrote a little letter to heads of Mathematics Departments in a number of universities and technical schools and asked them to give me any discussion of the subject which I might use as coming from them and especially to answer the following questions:

Should we emphasize the theoretical or the practical or should both be equally emphasized? How much use should be made of such instruments as the transit, the plane table, the sextant, etc.? Have you observed any weakness in our teaching of high school Trigonometry that should be overcome? I sent out only seven of these letters and I received six replies which I consider a remarkably high percentage and I wish to express my appreciation to the men who answered.

It would be interesting to read each of these six letters* and to discuss them separately but time will not permit. I shall try to summarize and bring out the important points made by each writer.

1. The first letter referred me to a book entitled, *The Teaching of Junior High School Mathematics*, and says that many of the reasons for teaching numerical Trigonometry

*Letters: 1. Teachers College. Columbia University. 2. Armour Institute of Technology. 3. University of Illinois. 4. Northwestern University. 5. University of Chicago. 6. University of Wisconsin.

are found there and the writer believes this the proper course in Trigonometry. The book referred to makes no mention of anything more than numerical Trigonometry which can be taught in the first year's work in Algebra.

2. The author of the second letter says that for the past ten years they have required all entering students to take a course in Trigonometry, a four hour course if the student presented no Trigonometry as entrance credit, a two hour course for those who have previously had the subject. The following is a direct quotation:

> "Judging from our experience, which is that of a technical school where all entrants must obtain a thorough working knowledge of Trigonometry, the greatest weakness in the teaching of Trigonometry in the secondary school is that too little emphasis is placed on the parts of the subject other than the solution of triangles. In our work we feel that greater emphasis should be placed on the transformation of expressions, the solution of trigonometrical equations, the manipulation of inverse formulas."

This writer recognizes the fact that not all of our students who take Trigonometry are preparing for engineering work and states that perhaps for those who are not, more emphasis should be placed upon the solution of triangles and the other immediate applications of the subject.

3. The writer of another letter explains that in their university they offer two courses in Trigonometry, one for students who have not had high school Trigonometry, the other for those who have had. They have found it necessary to give an examination early in the semester and on the basis of that examination to transfer some from the advanced course to the elementary. This writer furnished me a detailed tabulated result of that examination for each of two years which is exceedingly interesting but can not be presented in this paper. Suffice it to say that based on 70 as perfection the highest grade of any student transferred was 25 for one year and 29 for the other and that the number transferred the first year was 54 out of 225 enrolled, and for the other 55 out of 219. He states that his experience and that of others in his department is that the most common deficiency is the lack of any knowledge of trigonometric analysis as opposed to solution of triangles. Hand in hand with this goes the deficiency in Algebra. He finds many students who say that their course in high school Trigonometry included nothing or very little beyond right triangles.

4. Quoting directly from the fourth letter I have this:

"We mathematics people in college are certainly more interested in your teaching theory rather than practice. You can waste a lot of time with transits, sextants, etc. Few of your class will ever have any use for them, and the engineers (prospective) will have to be taught it all again anyway. Hence the use of these instruments is merely to amuse the class."

This man also points out that it really is the "theory" that is practical; and that by far the most efficient method of teaching the subject is "on the basis of daily, corrected exercises."

5. The two paragraphs which follow are quoted directly from the next letter:

"For the Trigonometry course in the high school I believe that the chief emphasis should be put upon the applications of the subject to practical problems of heights, distances, and surveying. It certainly offers a splendid opportunity to introduce to young students the very great advantage gained by mathematical considerations over any process of actual direct measurement, and the subject should be so presented as to constantly broaden the mind of the pupil with respect to the enlarged possibilities of doing practical things by mathematical processes."

"On the other hand I would by no means limit the class discussions to questions of practical applications. Of course, one cannot go very deeply into the theoretical side of Trigonometry with a high school class but it is possible to introduce such pupils to the consideration of the theoretical matters without involving them too deeply in the scientific considerations. Furthermore, some of these theoretical things are themselves attractive and interesting as examples of fine art and remarkable combinations of the trigonometric functions."

This writer expresses the opinion that Trigonometry is probably as well taught in the last year of high school as if it were taught in the first year of college.

6. The last letter of the six I shall quote in full, except a short introductory paragraph:

"In the very first place, I should say that the worst thing that can happen is to have a student take a poor or superficial course in Trigonometry in high school. This ruins trigonometry for him as a university subject and does not give him the information he ought to have. In other words, in so far as Trigonometry is taught in the high school, it ought to be taught well. I realize that this is a mere truism but it is a consideration that should be before us always.

"There are two things which students can and should get from a course in Trigonometry which I may characterize as a manipulative facility in the subject, and a real understanding of the subject. It seems to me that many of our people who have taken high school Trigonometry "understand" Trigonometry but have not had sufficient drill in definitions, fundamental formulas, values of the trigonometric functions for critical angles, etc., to obtain for them a proper facility in manipulation. It is hard for me to see just why this is so, for I realize that a high school course in Trigonometry contains a large amount of such drill.

"I somewhat wonder if too much time is not spent in the routine solution of triangles. This is, after all, more a matter of arithmetic

and the use of tables than of trigonometry proper. Furthermore, I should like very much that high school students of Trigonometry do not get the false idea that the chief aim and purpose of Trigonometry is to enable one to compute triangles. It is certainly unfortunate that at that particular stage in their advancement it is not possible for high school students to study the more important applications of trigonometric functions, but at least they should be emphatically and repeatedly told that the trigonometric functions have a usefulness far more significant than one would suspect if one only knew that they could be used in solving triangles. In other words, I believe that even high school students of trigonometry should have emphasized the periodic nature of the trigonometric functions. They can then surely appreciate that such functions are of the type necessary to describe periodic phenomena in nature. Even in high school, students can sit down and think of ten or twenty significant phenomena which are periodic, and they can at least appreciate that mathematics must make use of the trigonometric functions to describe and study such phenomena. This should help the students to appreciate the absolute necessity of a thorough knowledge of the fundamental relations between these periodic functions.

"I feel that it is interesting to phrase some of the triangle solving problems of Trigonometry in terms of surveying problems, as you suggest, but it would seem to me that such interpretation already receives as much emphasis as it deserves. As I have indicated above, it would seem to me much more important not to emphasize the impression which many high school students of Trigonometry have that such triangle solving is the sole aim of Trigonometry. Students should appreciate that the solving of triangles is an extremely useful, convenient, and interesting application of Trigonometry, but a relatively trivial application; the fundamentally important applications being the description and study of the periodic phenomena of nature."

Summing these letters briefly: One man indicates that no theory be taught, one believes that much emphasis should be placed upon the practical part of the subject but that the theoretical parts should by no means be neglected; the others all wish the major emphasis to be placed upon the theoretical, treating the practical measurements as a very useful and interesting part of the course but consuming a relatively small part of the time spent on the subject.

In view of the preceding discussion the specific aims of a course in high school Trigonometry may now be investigated. In a high school class in Trigonometry are we justified in treating the subject as a college preparatory course? My answer is that if it is necessary for us to consider the course as a course for any one particular purpose, then that purpose should be college preparation because there are beyond doubt more students taking Trigonometry who expect to use it as a college preparatory course than for any other one purpose. This does not, in my opinion, in any way handicap those who are not going to college, because

college requirements are not the requirements of a world entirely apart from the world in which most of us are living but quite the opposite. The college requirement should be, in a sense, an ideal toward which to strive so that the student who has gained a thorough knowledge of the subject for college purposes has also gained the best knowledge of the subject for almost any other purpose. Instead of saying the major aim of the course is college preparation, I would prefer to say my first aim is to give a thorough working knowledge of Trigonometry.

Other aims which I can mention are subordinate to this and are an answer to the question, what may one gain from a knowledge of Trigonometry? The answers which occur to me are as follows:

1. An insight into the usefulness of Mathematics is gained from Trigonometry far more than from any other branch of high school Mathematics. The indirect measurements of heights and distances and a small introduction to surveying is an eye opener to the student who has been always asking the question, "What is the use of Mathematics?"

2. The dependence of one quantity upon another, in other words the function idea can be brought out and presented more clearly in Trigonometry than in any other branch of Mathematics.

3. An introduction to the idea of mathematically describing periodic phenomena should certainly come in the graphical representation of the values of the trigonometric functions and will be further emphasized in other parts of the subject.

4. An appreciation of the beauty in the marvelous combinations of which the trigonometric functions are capable is a worthy aim in teaching this subject.

This list is not complete. You may add to it to your heart's content. It is not taken from the report of the national committee. It is not even taken from the syllabus prepared by teachers in Milwaukee. It is my own list and is no better and perhaps not as good as one you can make.

You may be interested to hear the aims and purposes for the course in Trigonometry which were set down by the teachers of Mathematics in Milwaukee when we prepared

a syllabus which was adopted in the year 1923. They are:

1. To develop in the pupil an understanding of the fundamental principles of Trigonometry and the ability to apply them to situations involving indirect measurement in the various fields of science and industry.

2. To give training in functional thinking through graphical representations of functional relations.

3. To develop the power of quantity and space perception and spatial imagination.

4. To develop an ability for application of principles previously learned in the Algebra and Geometry through the solution of trigonometric equations.

5. To further develop mental habits of analysis, exactness and logical organization, which will make the pupil's training effective in later life.

This discussion has become too long already, therefore, as to method, I shall have very little to say. We all realize that the personality of the teacher is what makes any method succeed or fail. In our school we are convinced that the moderate use of the transit and plane table in doing a very little work in heights, distances and very elementary surveys adds materially to the effectiveness of our teaching. To know what can be done with a transit and that so simple an instrument as a plane table can produce fairly accurate results has, we believe, some educational value.

In this paper, the history of Trigonometry has been referred to; the fact has been mentioned that Trigonometry has no central idea which gives it an individuality such as is found in other branches of high school mathematics; some opinions have been expressed as to where the chief emphasis should be placed; a statement of aims has been suggested; and a little of the method used in one school in teaching the subject has been stated.

I am well aware that this paper is in no sense complete. Its greatest imperfection perhaps lies in the fact that it deals with Trigonometry in relation to further study in Mathematics and does not deal with its relation to industries in which it might be used by the person who never goes to college. There are two reasons for this: 1. Time does not permit. 2. In our high school, which I believe is fairly representative, almost all who take Trigonometry expect to use it for college entrance or as the bases for

further study in Mathematics, the proportion this semester being 42 out of 45 enrolled.

Mathematics is one of the great branches of human knowledge. In high school no other branch of Mathematics opens so many avenues of thought as Trigonometry. The great purpose of education, to me, is to provoke thought and to inspire to noble living. Mathematics ranks with the first of our school subjects in producing that result.

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## HOW INSPIRATIONAL IS YOUR TEACHING?

By Frank W. Hanson,
*Wiltby High School, Waterbury, Conn.*

To every science teacher, successful or otherwise, there are times when the question of "interest" arises concerning the pupils and even the teacher himself. Not one of us would appear "dead" in the class room but unless we have a great love for the science, and a keen feeling that science is intimately connected with the life of the pupil, we will appear dead to those who are in our classes.

And so I want to deal with just one phase of science teaching that has helped me to hold my grip when otherwise I might more often sink into the commonplace. I refer to the inspiration of the masters, of those who have evolved out of science, the greatest of great achievements. I go to the outstanding characters and become again inspired, thrilled, buoyed up. And I carry that into the classroom. No class can resist the wonderfulness of the story of the life of a great man who has so stirred a mature teacher that the teacher is fired with the enthusiasm of youth. One of the most favorable comments that I ever received from a supervisor was on the day after I had read and absorbed the life story of Charles Hall and was giving it in my classes. And there are many characters that are laden with everlasting inspirations to those who would know them. Pasteur, Lister, Sir Humphrey Davy, Michael Faraday, Nobel and Sir William Perkin as well as many others are as a fountain of encouragement to every science teacher who would really lead his classes. And always use fresh fuel for your zest. The inspiration of a week ago is hardly suitable for today.

So if you would create and continue interest in your science courses be inspirational by getting frequently inspired. Uninteresting facts and routine problems and long, detailed processes may be necessary in your run of teaching but they may be made much easier going if you can feel and make your classes feel that these things were steps in the development of a great industry, of a country, of a civilization. One company puts out a book "The Romance of Cement" and another "The Romance of Rubber," but what kind of a topic or topics do the children in your classes find you presenting when these subjects come up.

Therefore for every new topic you take up find if you can the inspirational side of it. This may seem difficult but I have found it in coal, in neon, in nitrogen and in many other "dull" subjects. Follow this plan of inspiration in teaching. You may not become a great scientist but you will become a better teacher and greater leader of the minds of youth.

## THE TEACHING OF THE PRINCIPLE OF HOMOLOGIES TO ELEMENTARY CLASSES IN BIOLOGY, AND THE USE OF PHYLOGENETIC SERIES IN THE LABORATORY.

BY J. CHESTER BRADLEY,
*Cornell University, Ithaca, N. Y.*

All teachers of biology recognize that the discipline of that science involves, as one of its chief fundamentals, an appreciation of the significance of the homologies of organs; and that a student who at the end of a course in biology had no concept of how the simple and primitive condition of organs have been gradually modified along devious lines of increasing complexity, who in a word had no understanding of phylogenetic series, would totally have failed to acquire the biologists' point of view. The study of types is largely designed to impress this sort of thing upon the mind of the student, but that sort of study is not as fashionable as formerly, and even where it is pursued, it usually falls short of its purpose. The student is absorbed in the details of anatomy; the types are studied at such remote intervals that the student makes little connection between one and the other. Since he can study but one at a time, and has no chance for comparing them all together, he usually fails to understand what it is all about, to obtain the "Uebersicht" that would open his eyes to the processes of phylogeny.

If every elementary student could see and handle, in proper sequence, the series of fossils that eventuate in a horse's leg, or the wing of an Archaeopteryx alongside of skeletons of the fore-limb of a lizard, the pectoral fin of a fish, the arm of a man, and the flipper of a whale, he would be well served. But these things are too bulky for practical laboratory work, and for other reasons not available.

The writer believes that the most readily available and altogether satisfactory phylogenetic series that can be placed before all elementary students, even in large laboratory sections, consists of a selected *small* series of insects wings; and for the reasons that follow:

1. By the method that has been in use in the writer's laboratory for very many years, accurate drawings of each wing studied can be very rapidly made.

2. These wing-plates can be definitely connected in the minds of the students with the actual insects which they

represent by the presence in the laboratory of demonstration specimens of the entire insects.

3. The wing-plates, thus drawn, are neither too small and obscure, nor too large and bulky to be handled *all together* on the laboratory table, by *each* student. He can spread them out on his desk and arrange them in various ways, to suit himself, and will find that they lead him, step by step, along various lines of modification, until end results are attained so astonishingly different from the starting point that no one could ever have understood how they came about, or what their homologies were, except in the light of such a comparative study.

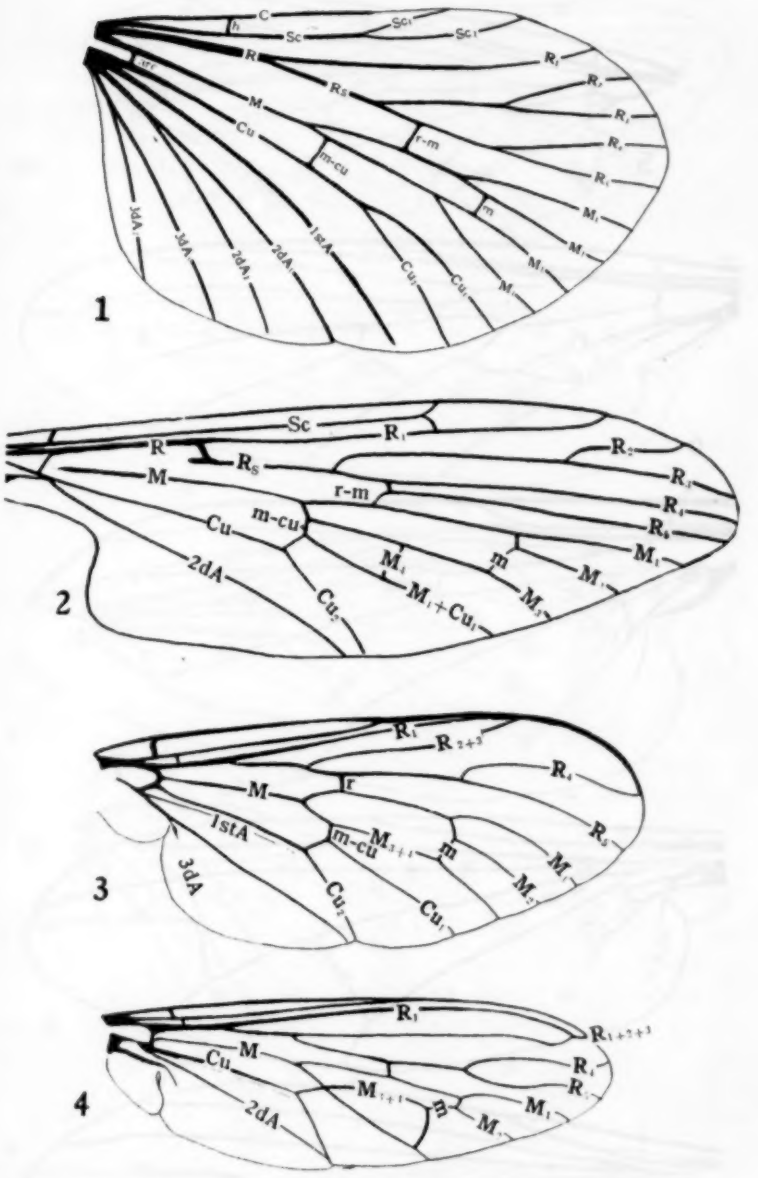
4. The series of twelve insects, suggested below, represents three major lines of modification, with progressive steps along two of those lines. The student may therefore correlate his work at the end by constructing a phylogenetic tree, on which he can allocate all of the forms studied. The characters of the forms selected are such that their allocation will not be by hazily guessing that one seems probably more primitive, or more like this or that, but the student will be able to assign very definite reasons for each allocation, and to indicate on the key, what modification taking place along each interval has become definitive of the next succeeding form or forms.

5. Basing his work on the diagrams of the venation of an archetypal insect wing, and with help from the instructor (or printed instructions) in applying the method to the first wing studied, the student can proceed independently, without further help, to the logical interpretation of what has happened at each successive stage of modification of the venation in the wings of the eleven insects that remain.

6. Studied in this way, the whole exercise proves of absorbing interest to most students. It becomes analagous in method to a very small problem of original research, and not infrequently awakens a little of the enthusiasm of a potential research worker.

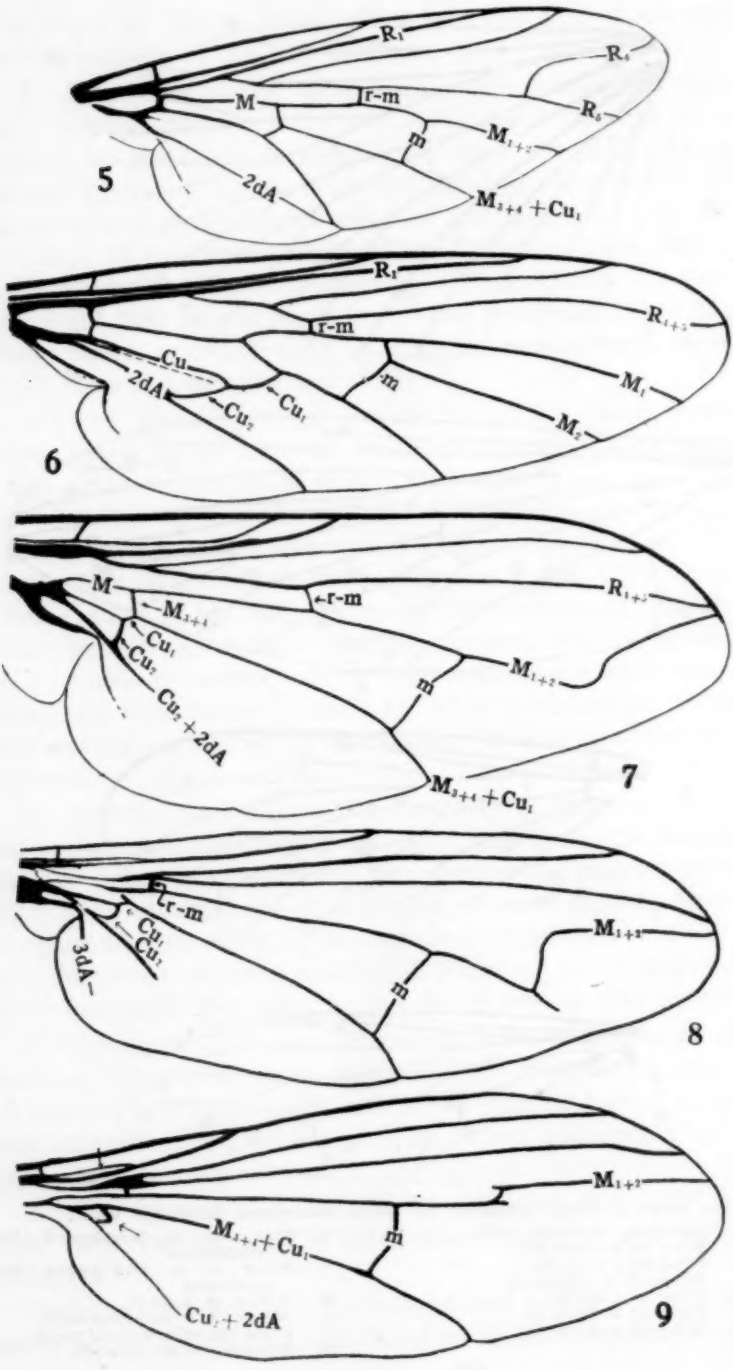
7. The exercises, if carried on as above suggested, afford very real training in independent, precise, and logical thinking.

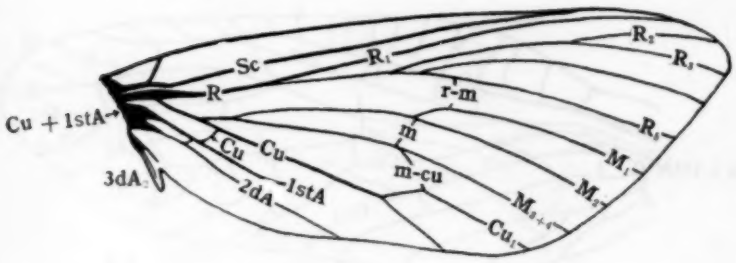
Perhaps nowhere in the whole animal world is there another organ which has registered so diagrammatically the

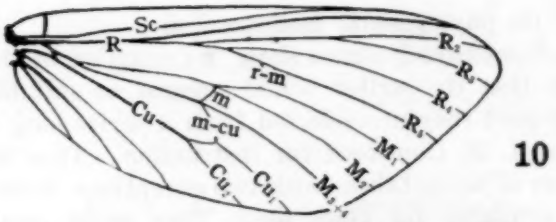



The series of wings suggested for use in elementary laboratory work:

1. Archetype of insect wing
2. Wing of a crane-fly
3. Wing of a snipe-fly
4. Wing of a robber-fly
5. Wing of a bee-fly
6. Wing of a dance-fly
7. Wing of a house-fly
8. Wing of a long-legged fly: *Psilopodinus*
9. Wing of a long-legged fly: *Dolichopus*
10. Wings of a swift
11. Wings of a carpenter-moth
12. Forewing of a noctuid moth
13. Forewing of an alder-fly


R1
R5
M
r-m
R4
m
M1+2
2dA
M3+4 + Cu1
5
R1
R1+2
r-m
Cu
2dA
Cu1
Cu2
m
M1
M2
6
M
M3+4
r-m
R1+2
Cu1
Cu2
M1+2
m
Cu2 + 2dA
M3+4 + Cu1
7
r-m
Cu1
Cu2
3dA
M1+2
m
8
M1+2
M3+4 + Cu1
m
Cu2 + 2dA
9


Sc
R
R1
R2
R3
R4
R5
r-m
m
m-cu
M1
M2
M3+4
Cu1
Cu2
Cu + 1stA
3dA
2dA
1stA


Sc
R
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Cu
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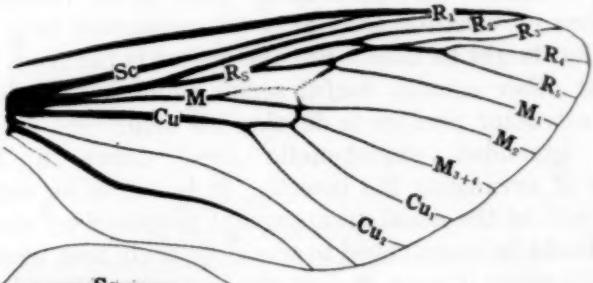
M3+4
Cu2
Cu1

10


R1
R2
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Sc
Rs
R5
M
M1
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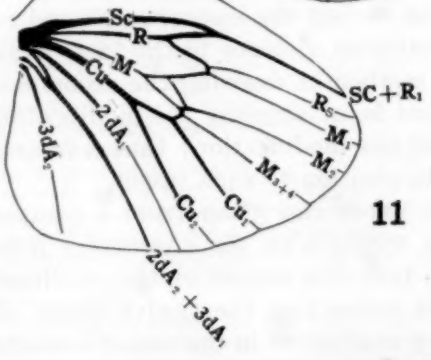
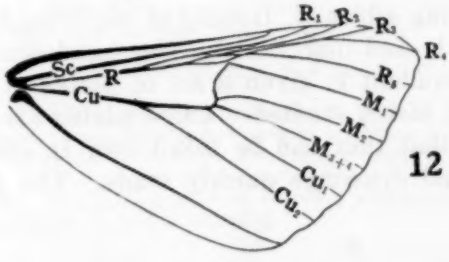
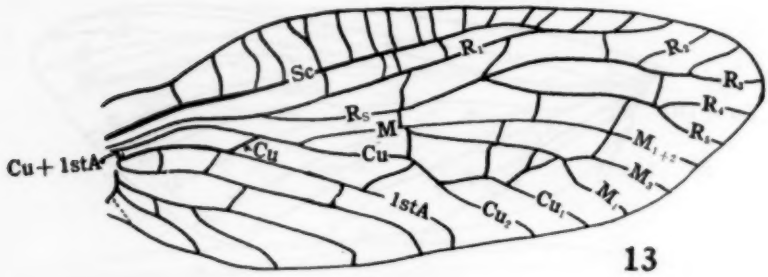
M3+4
Cu1
Cu2


Sc
R
M
Cu
SC+R1
Rs
M1
M2
M3+4
Cu1
Cu2
2dA1
3dA2
2dA2+3dA1

11


R1
R2
R3
R4
Sc
R
Cu
R5
M1
M2
M3+4
Cu1
Cu2

12




13

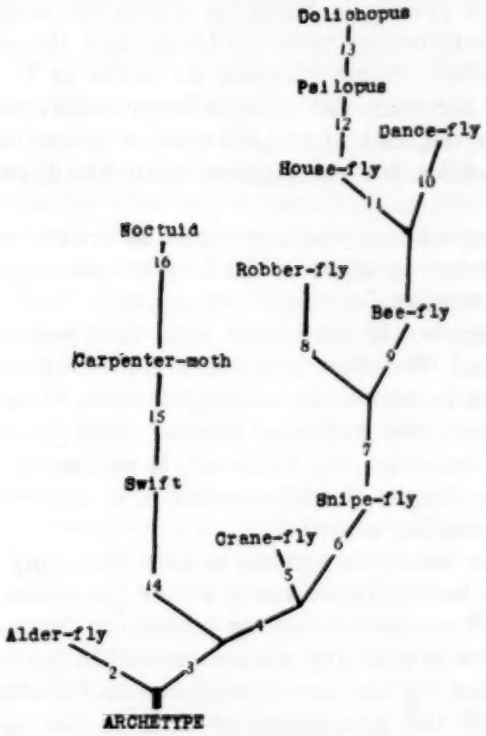
story of its phylogenetic modification.

The accompanying plates show the venation of the series of wings that the writer would suggest as suitable. For the most part they are selected from a series long used by Professor J. H. Comstock for instruction. They have the advantage of being taken, with two exceptions, from insects readily available for class use. They avoid complicated conditions of venation that arise in connection with other series that might be used. But the writer is far from thinking that other equally useful series could not be devised, if the instructor prefers to develop his own.

The appended phylogenetic tree shows a logical method of arranging the insects. It is not to be supposed that it will be the usual arrangement proposed by students. They should be encouraged to work out their own ideas, and to defend them if need be, but the instructor should refuse to accept any plan that does violence to the facts available to the student. The method of drawing the accompanying tree is important—that is, of showing the modifications at each point (or at least one modification) that warrants the assigning of a definite position to each insect.

The reader of this paper can glean from a comparison of the figures of the wings with the characters noted at each point along the tree, the extent of the modifications and the nature of the series that the twelve wings afford.

Rapidity of drawing is attained in the writer's laboratory by the following scheme: Instead of requiring the students to make slowly and inaccurately, free hand drawings from slides, each student is given a set of plates of the wings, one for each insect studied. These plates are printed in pale ink, so that they can be inked over in color, and accurate finished drawings quickly made. The relations of




A PHYLOGENETIC TREE.

**List of characters developed at points indicated.**

1. ARCHETYPE. Possesses 8 longitudinal veins, branched according to plan of figure 1.
2. Accessory veins developed.
3. 1st A tends toward reduction.
4. Loss of hind pair of wings.
5. $M_4$ unites with $Cu_1$ at apex.
6. $R_2$ and $R_3$ unite.
7. Tip of $M_{3+4}$ unites with $Cu_1$.
8. Tip of $R_1$ unites with $R_{2+3}$.
9. $M_{3+4}$ unites completly with $Cu_1$; $M_1$ and $M_2$ unite; origins of $M_{3+4}$ and of $Cu_1$ recede toward wing base.
10. $Cu_2$ swings backward, toward wing base; apex of Sc unites with $R_1$.
11. Tip of $M_{1+2}$ turns upward toward $R_5$; origins of $M_{3+4}$ and of $Cu_1$ recede farther.
12. $Cu_2$ swings backward toward wing base; origin of $Cu_1$ recedes still farther; $M_{1+2}$ makes two bends and developes a spur; *r* moves toward wing base; base of $M_{3+4}$ partly atrophied; apex of Sc unites with $R_1$.
13. Bends of $M_{1+2}$ develop into sharp angles, each with a spur; base of $M_{3+4}$ completely disappears.
14. Sc becomes one-branched; $M_3$ and $M_4$ unite; 1st A is lost in the hind wing.
15. Cell $R_3$ divided by a short coalescence of $R_3$ with $R_{4+5}$ in the forewing. Rs reduced to one branch and apex of Sc unites with $R_1$ in the hind wing; 2nd $A_2$ and 3d $A_1$ unite in the hind wing; 1st A lost in the fore wing.
16. Bases of $M_1$, $M_{1+2}$, $M_{3+4}$ all lost, forming a large discal cell; 2nd $A_2$ unites with 3d $A_1$ in the forewing.

the veins are greatly clarified by inking the media in red, the other longitudinal veins in black, and the cross-veins in a third color. Some students go so far as to use a different color for each of the eight longitudinal veins. It is desirable for the student to have a set of wings mounted on microscope-slides for comparison with his drawing, time permitting.

It is of importance that the wings be drawn on separate plates, in order to allow of their free rearrangement by students in working out their phylogeny.

If the exercises involve more time than can be allowed, about one and three-quarters hours can be saved by labelling the veins in pencil, not inking the veins, but using a red pencil to mark the course of media. Still more time (at sacrifice of training) can be saved, if necessary, by giving the students clues to the interpretation of the veins as they take up succeeding plates.

The writer would be pleased to hear from any one interested in the possibility of using either the series of insects suggested, or another series for laboratory instruction, and would be glad to lend any assistance within his power. He has an outline for the use of students, and another for the assistance of the instructor, as well as the set of wing plates, printed in pale grey ink, all of which can be made available, if desired. It may prove possible, should demand arise, to arrange to make available mounted sets of the entire insects for demonstration, and mounted slides of the wings.

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## CALENDAR REFORM.

The *University Association for the Study of Calendar Reform* has been organized by a group interested in improving the calendar, but not committed in advance to some particular plan of alteration.

The members of this association believe that, following the experimental method of modern science, there should be a trial, without legislative alteration, of various proposals, and a study of the results before any overhauling of the calendar is recommended. It has been pointed out that business men and others can obtain the essential advantages by a simple plan which does not require a League of Nations agreement, an act of Congress, or any legislation whatever, and as a first step in the study of calendar simplification, the trial of such a plan by persons interested is suggested.

R. C. Flickinger, of the University of Iowa, Iowa City, Iowa, and Jakob Kunz, of the University of Illinois, Urbana, Illinois, are joint chairmen. C. C. Wylie, of the University of Iowa, Iowa City, Iowa, is Secretary-Treasurer.

## MEASURING THE PERFORMANCE OF AN AUTOMOBILE.

By N. HENRY BLACK,
*Harvard University, Cambridge, Mass.*

There is probably no machine so much used by the general public as the automobile, and yet how blissfully ignorant most of us are about its real performance! We know the make and the year of its manufacture and perhaps its maximum speed. We may realize that one car "picks up" speed faster than another, but we have no way of measuring this "liveliness" of the car. We may know that a certain car will climb a given hill "on high," but we do not know the steepness of the hill or the weight of the car. Only a few people keep track of the consumption of gasoline and oil, and the mileage covered; so that about all we know about our automobiles is that they go. The wonder is that they go so well!

Recently I came upon a little instrument known as the Tapley Performance Meter, which enables one to get a surprising amount of information about the behavior of his car. For example, with it one can measure the *driving force*, the *tractive resistance*, the *air resistance*, the *brake horse power*, the *engine friction*, and the *brake holding capacity* of a car. These tests require only a few minutes of time and might well be made periodically in order to find out whether or not the automobile is running efficiently and economically. Since the abuse of our automobiles is one of our most glaring national sins, it seemed to me worth while at this time to call this meter to the attention of the American physics teachers.

This instrument* (Fig. 1) is about 3.5 inches in diameter and may be attached to the instrument board of any automobile or clamped on the post of the steering wheel. It has two revolving scales—one (left) showing the pulling power in pounds per ton weight of the car and the other (right) showing the road gradient. In America and most European countries, gradients are expressed as a percentage, the horizontal distance in this case being taken as 100 and the steepness represented by the vertical rise or fall. Thus a 5 per cent grade means a vertical rise or fall of 5 feet in a horizontal distance of 100 feet.

*Made by Tapley and Company, Totton, Southampton, England. U. S. A. Agent: E. C. Cheswell, Melrose Highlands 77, Mass.

When the gradient scale indicates 10 on the right scale, the other scale indicates 200 pounds per ton. Thus it will be seen that the pull is 10 per cent of a ton. But if the loaded car weighs 3400 lbs., then the actual pull, or driving force, is 340 pounds. Again, when the gradient scale reads 15, the left-hand scale will read 15% of 2000 lbs., or 300 lbs. per ton. Thus it is seen that the two scales are attached to the same drum and move together.

When the automobile is retarded instead of accelerated, the drum with its two scales revolves in the opposite direction and the scale shows white figures on a black background instead of the usual black figures on a white background. The left scale in this case shows the braking force and the right scale the gradient, or steepness of grade. In other words, it indicates the vertical drop in a horizontal distance of 100 feet.

FIG. 1. TAPLEY PERFORMANCE METER SHOWING THE REVOLVING SCALES. PULLING POWER (LBS PER TON) ON LEFT AND ROAD GRADIENT (PER CENT) ON RIGHT.

*How the meter works.* We are all familiar with the "plumb-bob" as a device for getting a vertical line. Now, when a plumb-bob is carried in a moving vehicle, the bob does not necessarily hang directly below the point of support. If the vehicle is gaining speed, then the plumb-bob, or pendulum, swings backward because of its own inertia,

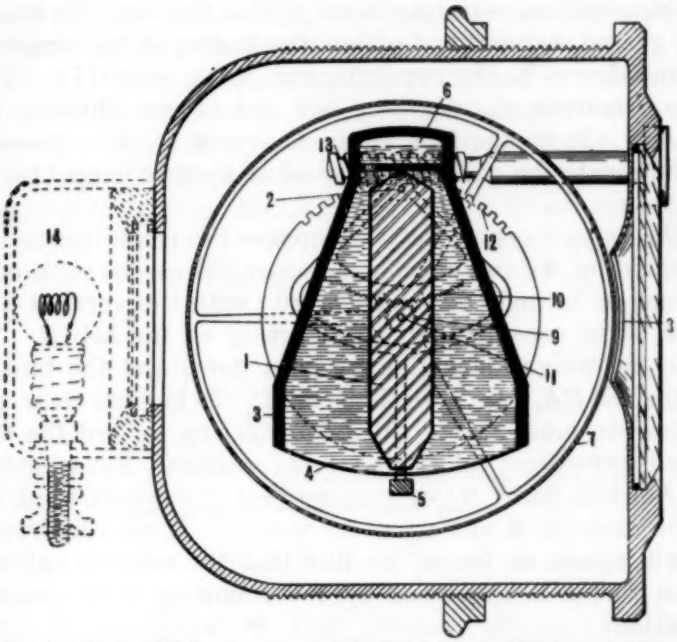



FIG. 2. CROSS SECTION OF THE PERFORMANCE METER. 1, PERMANENT-MAGNET PENDULUM; 2, POINTS OF SUSPENSION; 3, BOX WITH DAMPING FLUID; 4, THIN COPPER BOTTOM; 5, IRON ARMATURE; 7, REVOLVING SCALES; 8, WINDOW IN FACE PLATE; 14, ELECTRIC LAMP FOR ILLUMINATING SCALE.

and the greater the acceleration the greater is the backward swing. If the vehicle is retarded, then for the same reason the pendulum swings forward. But if the vehicle is moving steadily, neither gaining nor losing speed, the pendulum hangs vertically in the same position as when at rest.

Of course we can not make a practical instrument by simply suspending a plumb-bob or pendulum in a car which is moving, for the swaying of the car would make the pendulum oscillate in an erratic fashion. In the commercial instrument the pendulum is suspended in a box which is filled with a damping fluid and hermetically sealed. To get the movements of this enclosed pendulum conveyed to the scale mechanism is the next problem. The pendulum, as shown in figure 2, is a permanent magnet (1) suspended on centers at (2) and enclosed in the box (3). But the bottom of the box is a thin curved copper plate (4), and outside is an iron armature (5) supported from centers in line with those of the magnet. This armature follows the swing of

the steadied magnetic pendulum within the box. By means of a geared segment and pinion, the motion of the armature is transferred to the revolving indicating scale (7). This latter encircles the damping box and is seen through the window (8) in the face of the instrument. It is possible to illuminate the scale by means of an electric lamp (14) in the rear.

*The physics of the meter.* Suppose the pendulum is represented by $AB$ in figure 3. Suppose the acceleration of $A$ is such as to make an angle of 20° with the vertical line. Now let us consider the forces acting on the bob $B$. We have the weight $W$ acting straight down and the tension on the rod $BA$, which we shall call $T$. To balance these two forces, we must have a third force acting toward the left. This is sometimes called the *inertia reaction.* But whatever we call this force $H$, we can see that it depends upon the angle made at $A$ and upon the weight. If we construct a parallelogram of forces, we find that the relation between these forces is expressed by the following trigonometric equation:

$$H = \tan 20° \times W = 0.344\ W.$$

If $W$ is the weight of the car, then $H$ is the pull, or driving force, which is accelerating the car so fast that a pendulum swings back 20°.

FIG. 3. DIAGRAM OF FORCES ACTING ON PENDULUM IN MOVING CAR.

Now the manufacturers have made the gradient scale (right) so that it registers the ratio of $H$ to $W$, or the tangent of the angle of the pendulum, because this also gives the gradient, or steepness, of the road when the car is mov-

ing steadily. These facts can perhaps be more quickly grasped by the following diagrams.

Figure 4 shows a car weighing 2000 pounds and accelerating along a level road. Let $P$ be the force needed to overcome the frictional resistance $R$. Then the spring balance P′ will measure the driving pull, or unbalanced force, which produces the acceleration. If this force is 10 per cent of the weight of the car (or 200 pounds), then the performance meter indicates 10 on the right scale.

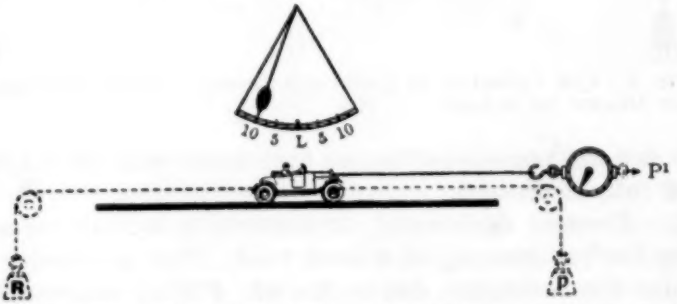



FIG. 4. CAR (WT. 2000 LBS.) ACCELERATING ON LEVEL ROAD. SPRING BALANCE P′ INDICATES A PUSH OF 200 LBS., OR 10 PER CENT OF THE WEIGHT.

Figure 5 shows a car climbing a gradient of 10 per cent at constant speed. The gradient is not drawn to scale. If the car weighs 2000 pounds, then the pull, or force, needed to keep it moving steadily up grade (neglecting friction) is almost 200 pounds, or 10% of the weight of the car. Of course the length of the incline for this grade is about 0.5 of 1% more than the base, and actually the force is to the weight as the height is to the distance along the incline. But this error is not large enough to interfere with our experiments*.

## WHAT CAN WE DO WITH THE METER?

1. *Driving force.* This force can be easily determined directly by reading the left scale of the performance meter after it has been properly installed. This is the force which determines how fast you can pick up speed, and it is this force which determines the hill-climbing ability of the car. Most modern automobiles are built to give a pull of between

*The gradient scale on the meter is a *tangent* scale, but the lbs.-per-ton is a *sine* scale which is correct on a hill, but strictly speaking incorrect for the accelerating pull on the level. But the difference here is negligible at all ordinary rates of acceleration.

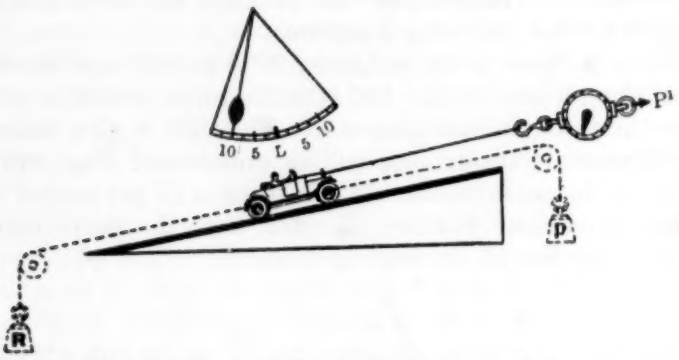



FIG 5. CAR CLIMBING AT CONSTANT SPEED A 10 PER CENT GRADE (NOT DRAWN TO SCALE).

120 and 220 pounds per ton on high speed with the accelerator fully depressed.

2. *Tractive resistance.* It requires a certain force to keep the car moving on a level road. This resistance includes the resistance due to the air ("wind resistance"), the frictional resistance of the mechanism of the car, and the rolling resistance of the wheels on the road. This tractive resistance probably accounts for more than 90 per cent of the fuel used. Therefore it is important to keep this resistance as low as possible. Since the wind resistance increases very rapidly with the speed, it is necessary to specify the speed at which this test is made. For example, at 15 miles per hour on a good road the tractive resistance should never exceed 50 pounds per ton. To measure this tractive resistance, depress the clutch while the car is moving along a level road or one that has a very slight decline. The car should be travelling a little faster than the speed at which the resistance is to be measured. The reading of the performance meter is taken as the speedometer drops to the required speed after depressing the clutch. For example, when the clutch is depressed and speed is 15 miles an hour, the meter reads 45 pounds per ton. This means that the tractive resistance at 15 m. p. h. is 45 lbs. per ton.

3. *Acceleration.* The actual rate at which a car is gaining speed may be expressed as the speed in miles per hour added each second. For example if a car is moving 20 miles per hour and one second later its speed is 22 miles per hour, then it is accelerating at the rate of 2 miles-per-hour per sec-

ond. To determine the rate of acceleration by the performance meter, we have only to read off the gradient on the right scale and multiply this gradient figure as per cent by 22, and the result is the acceleration in miles-per-hour per second. If you prefer to have the acceleration expressed in feet-per-second per second, multiply the gradient figure (as per cent) by 32. The reason for this method of computation is seen if we recall that according to the Second Law of Motion.

$$\frac{F}{W} = \frac{a}{g}$$

or $$a = \frac{F}{W} g.$$

Now the gradient figure (as per cent) is the value of $F/W$, and $g$ (the acceleration of gravity) is 32 feet-per-second per second, or 22 miles-per-hour per second. For example, a car is driven at 10 miles per hour and the gradient scale indicates level. But on depressing the accelerator, the maximum gradient reading on the right scale was 8. Therefore the acceleration is 0.08 of 22 or about 1.76 miles-per-hour per second, or 0.08 of 32, or about 2.56 feet-per-second per second.

4. *Brake horse power.* We are all familiar with the formulas used by government officials to figure out the nominal horse power of the engine in an automobile for purposes of taxation. But these formulas give very crude and often ridiculous results. In a testing laboratory an engine may be coupled up to an electric generator and its output measured at various speeds. What we need, however, is a method of measuring the brake horse power of an automobile engine without removing it from the car to a testing laboratory. This can be done by adding the tractive resistance and the gradient resistance in pounds per ton together, then multiplying this total resistance by the speed expressed in miles per hour and by the weight of the car expressed in hundred-weight, and dividing the product by 7500 to reduce the answer to horse power. For example, suppose a car weighing 2500 pounds (25 cwt.) when travelling 30 miles per hour was found to have a tractive resistance of 115 pounds per ton. Suppose also that when climbing a gradient at 30 miles per hour the

resistance is 150 pounds per ton. Then the total resistance is 115 plus 150, or 265 pounds per ton, and the horse power is $\frac{265\times30\times25}{7500}$, or 26.5 brake horse power*. This is the actual power developed at 30 miles per hour, and with gas engines the output of power varies greatly with the speed.

5. *Brake holding capacity.* One way of measuring the effectiveness of the brakes on a car is to measure the steepness, or gradient, of a slope upon which the brakes will hold the car, assuming that the wheels do not skid or slip. With a performance meter one has merely to depress the clutch when the car is moving on the level or on a down grade and then note the maximum gradient reading on the right scale when the brakes are applied. This test should be tried with the foot brakes and also with the hand brakes. For city traffic a gradient of 30% should be considered the minimum, but with four-wheel brakes in good condition 40% should be obtained.

6. *Air resistance.* The air resistance can be roughly measured by reading the tractive resistance at low speed and subtracting it from the tractive resistance at high speed. In this way it may be shown that air resistance increases when the speed increases. This resistance is not very important for the average motorist, but in the racing car the air resistance is so great that special care must be taken to design the shape and size of the car for minimum air resistance. This resistance varies widely with different cars.

7. *Engine friction.* The engine should be run long enough to be thoroughly warmed up. This test is valuable as an indication of defective lubrication. First measure the tractive resistance as already described and then repeat the measurement with the ignition switched off. The difference between the tractive resistance under these two conditions is the resistance caused by turning over the engine. For example, suppose a car on a slight incline is moving 25 miles per hour with the clutch out (or depressed). In this case the performance meter reads 75

*The reason for this equation is seen in these fundamental equations:

$$\text{Horse power} = \frac{\text{force (lbs.)} \times \text{distance (ft.) per minute}}{33{,}000}$$

$$= \frac{265\times25\times100}{2000} \times \frac{30\times5280}{60} \times \frac{1}{33{,}000} = \frac{265\times25\times30}{7500} = 26.5$$

pounds. But when the engine ignition is switched off and the car is making the same speed, the meter indicates 112 pounds. The difference between 112 and 75 pounds, or 37 pounds, per ton is the engine friction at 25 miles per hour.

It is often interesting to know the actual *gradient* of a road. When the car is moving at constant speed the right-hand scale registers this directly. But if the speed is not steady, we must apply the accelerator or brakes before the meter will indicate the correct road gradient. As with any such instrument sufficient time must always be allowed for the instrument to adjust itself to the new conditions. In other words, there is a certain "time lag."

Since this instrument has to be built with the delicacy of a watch and the sturdiness of a speedometer, it is not cheap*. But even if the meter is too expensive for the small high school, yet every well equipped garage and automobile station should have one and use it. I am sure that all teachers of physics will be glad to know that there is now available a commercial instrument which enables one to illustrate Newton's Second Law of Motion as applied to the automobile.

*Because of our benevolent high tariff I suspect that this meter will cost in the U. S. A. about $50.00.

## FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
*The University of Oklahoma, Norman, Okla.*

We laugh at the people of 600 years ago because they thought that coal was not fit to burn. But will not the people of 600 years hence laugh at us because we thought that coal was fit for nothing but to burn?—*Edwin E. Slosson.*

It is a mortifying truth, and ought to teach the wisest of us humility, that many of the most valuable discoveries have been the result of chance, rather than of contemplation, and of accident, rather than of design.—*Colton.*

Over the portal of a European cathedral is the inscription in Latin, "As if never to return." Do each task as if it were your last chance at it, and make this habitual.—*Joseph Whitefield Scroggs, "Problems of Personal Development."*

Difficulties cease to trouble us either when they are surmounted, or when we have become accustomed to them. As soon as we observe a rare phenomenon, our brain starts working to find some plausible explanation, while matters of daily occurrence, which may be the most puzzling of all, are treated with indifference. Every one, for instance, wants to know why a comet has a tail, yet how few ever trouble to think why the sky is blue or the sunset red.—*Arthur Schuster, "Progress of Physics."*

## A NEW METHOD OF TESTING THE RESULTS OF PERFORMING LABORATORY EXPERIMENTS.

By John M. Michener and J. A. Brownlee,
*Wichita High School East, and*

James A. Glover,
*Wichita High School North, Wichita, Kan.*

It is always the hope of the instructor in chemistry that when an experiment in the laboratory is performed, the students have acquired not only a knowledge of the results of the experiment, but also the ability to apply those results to other similar situations. For accomplishing this, several methods are used. The commonly used method, requiring much time of student and instructor in preparing and checking respectively, is that of the complete write up of the experiment. This method has been modified by having the students fill in blank forms, furnishing a partially written report and saving time and work for student and teacher. A third method,[1] that of reports on small cards is used by some teachers. This shortens the teacher's time. A fourth method, used by a few, is to give a test over the experiment when it is completed by all the students. Some object that this requires all the students to proceed at an even front, and in adjusting for slow and absent pupils, the test is long delayed or a second test must be administered. This method has been described in detail also.[2]

The object of this article is to describe a method used by the authors with the advantages of the method last mentioned, but without its disadvantages.

A test is given to each student on each experiment as soon as the experiment is finished. The test consists of twenty questions and the mechanics of it are such that it can be graded in about fifteen seconds, and at the same time the correct answers can be shown. In brief, the student after finishing an experiment takes a test, discovers his errors, and also learns the correct answers. This is now the third year that we have been using this method, and we are still enthusiastic about it. We have devised such tests

[1] Journal of Chemical Education, *3*, 1313 (Nov. 1926)
[2] School Science and Mathematics, *27*, 745 (October, 1927)
Journal of Chemical Education, *4*, 1043 (August, 1927)
Journal of Chemical Education, *7*, 1642-4 (July, 1930)

for sixty-five different experiments, as given in "Laboratory Studies in Chemistry" by Bradbury. We are now altering these tests so that they will fit similar experiments in Bruce's "Laboratory Manual of High School Chemistry." On a group of related experiments a review test is given, the questions of which are taken from the tests over the individual experiments. As the questions chosen are those that have proved to be the more difficult ones, these review tests stimulate the retention of information by the students.

Students keep their data on experiments in small notebooks, which, although looked over from time to time by the instructor, are not graded, but are used for reference material in studying for the test, supplemented by the sections of the textbook covering the experiment, to which the students are carefully directed.

The questions are not all fact questions, but many require considerable reasoning from the facts learned in the experiment. The test on a given experiment, while always the same one, is so administered that there is little transfer of answers from one student to another.

Each test is printed on a punched cardboard, 8″x11½″, as shown in the illustration. A typical set of twenty questions is appended at the end of this article. The questions are of the multiple choice type, and before each choice is written a capital letter. The writing of these capital letters is the only routine work done by the teacher in preparing the tests. By this means, the code can be varied from one sheet to another. All other work on the cardboard is done by mimeographing or printing. The student reads the first question, which for example might be this: The ratio by volume of hydrogen and oxygen when mixed for violent explosions should be the same as that obtained for those two gases from:

H—water
O—acid
P—gas
Q—air
R—hydrogen peroxide

If the student decides that "water" is the correct answer, he writes the letter "H" on a sheet of paper which has been previously clipped back of the cardboard. He writes this

through the hole which is punched in the cardboard in the lower right hand corner of the section given over to this particular question. Similarly, he indicates his answer to each of the other questions. The number of answers from which he has to choose is very seldom as few as two, and is often as many as six or seven. When he has completed answering the test, he brings the two sheets to the instructor who can rapidly look over the twenty letters, and indicate each mistake by writing over it the correct letter.

The instructor can do this in about fifteen seconds on the average, because the correct letters make either a sentence, or a name when read across the sheet in a certain direction. We vary these names or sentences on every sheet and also we vary the order in which the letters have to be read across the sheet. The particular variation used is indicated by a combination of three or four letters and figures in the upper right hand corner of the sheet.

The accompanying illustration is of a paper turned in by a student with arrows added to indicate the order in spelling out the code which is: L E V I T I C U S N U M - B E R S D E U T.

About six different orders and an indefinite number of sentences or combinations of names are used, which involves little memory work by the teacher; yet such combinations are difficult for anyone trying to decipher the code used on an individual sheet. No two sheets on the same experiment, and very few of the entire number, have the same code. Furthermore, the sequence of the answers for each question is changed from one sheet to another. To catch cheaters, often the simplest code is followed for about fifteen letters in putting on the code, and then on the last five the next succeeding letter of the alphabet is placed in front of the correct answer, at the same time putting the letter indicated by the code in front of an incorrect answer. If the student has any tendency to cheat on the tests, and tries to discover the code sentence used, he would, if successful at all, hit upon this easiest code. He would then follow out the code and indicate the correct answers except upon the last five questions. In this way, those who try to cheat are caught, and students are soon convinced that it is unwise to pursue such a policy as sooner or later they are

Name | Grade | Trial | Sheet No

Date Started | Period

Title: Carbon Dioxide in, etc C-1

Date Finished | Exp No.

The solubility of barium hydroxide as compared with that of calcium hydroxide is
- greater
- less
- the same
- greater

2
The per cent of carbon dioxide in the air is between :
- 0-1
- 1-2
- 2-3
- 3-4
- 5-6
- 4-5

3
In aspired air, the amount of carbon dioxide is :
- greater than
- less than
- the same as
- greater than the amount in the air inhaled.

4
Ordinary combustibles burn readily in carbon dioxide.
- true
- false
- true

5
The following reduces the amount of carbon dioxide in the air :
- plants
- fires
- animals
- eating
- plants

6
The following pair increases the amount of carbon dioxide in the air
- animals and plants
- fires and animals
- plants and fires
- animals and plants

7
The white precipitate formed in limewater by carbon dioxide is
- barium carbonate
- calcium carbonate
- barium hydroxide
- calcium hydroxide
- barium carbonate

8
Carbon dioxide dissolves in water and combines with it to form
- barium carbonate
- calcium carbonate
- carbonic acid
- barium hydroxide
- calcium hydroxide

9
The color of barium carbonate is
- black
- white
- yellow
- blue
- black

10
In a more concentrated solution of a substance, the percent of the substance present is :
- greater than
- smaller than
- the same as the proportion of the substance in a less concentrated solution.

11
The carbon in carbon dioxide is in the
- oxidized
- reduced
- oxidized state

12
In the formation of carbon dioxide from carbon and oxygen heat energy is :
- produced from
- changed into
- produced from chemical energy

13
The most plentiful gas in dry air is :
- oxygen
- nitrogen
- argon
- carbon dioxide
- hydrogen
- oxygen

14
The 4th most plentiful gas in dry air is
- oxygen
- nitrogen
- argon
- carbon dioxide
- hydrogen
- oxygen

15
The 3rd most plentiful gas in dry air is
- nitrogen
- oxygen
- carbon dioxide
- hydrogen
- argon
- water vapor
- nitrogen

16
The 4th most plentiful gas in dry air is
- water vapor
- oxygen
- carbon dioxide
- hydrogen
- argon
- nitrogen
- water vapor

17
The source of carbon in the carbon dioxide of the expired air is the
- air
- food
- water
- air

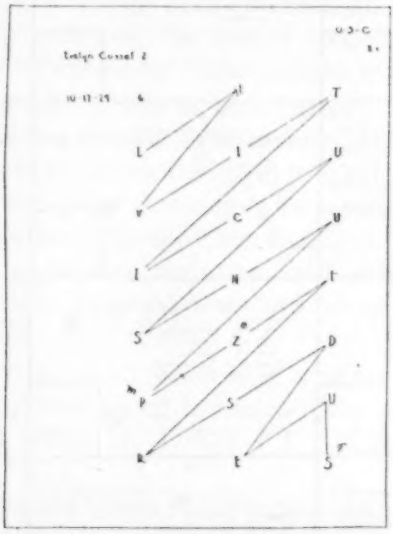
18
In the formation of carbon dioxide in the body the body
- gains
- loses
- gains
energy in the form of heat

19
The following increases the amount of oxygen in the air
- plants
- animals
- fires
- crushing

20
In order to collect a gas over water in the pneumatic trough the solubility of the gas in water must be
- great
- small
- of small effect
- great

A SAMPLE OF PRINTED TEST. CODE IS YET TO BE ADDED

discovered. Another point of mechanics helps also. Students are required to sit at certain easily observed places in the room while taking the tests. As a result, we think there is practically no attempt at transfer of answers from one student to another except by actual memorizing of questions and answers.



TYPICAL STUDENT'S PAPER, SHOWING HOW CODE IS READ.

If the student misses more than seven questions out of the twenty he is given a grade of five on a basis of ten. Usually he is allowed to see the correct answers and at some later date, is required to repeat the test. In the meantime he is making a more thorough study of the experiment or performing a part or all of it over again. Such a procedure is repeated, if necessary, until the student can take the test with a grade of six and one-half or better on a basis of ten. The student's score on a test is the average score from taking the test one or more times. At the end of the term in making out grades, the term total is taken and pupils ranked according to the normal curve for a grade in laboratory chemistry.

This procedure saves an immense lot of time on the part of a student, as not more than fifteen minutes are required to take such a test and the teacher can grade it in a few seconds and can easily record all of the graded experiments for the day in a few minutes.

This method is a definite check on the particular points of the experiment that the student does not understand, and affords the teacher an excellent opportunity to discuss them with the student. It also enables the teacher to determine the difficult parts of each experiment, by studying test results and thereby discovering the difficult questions on the test.

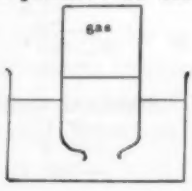
Of course, such a method of checking laboratory experiments can be used in any other science course, and the method of checking answers to such questions can be used in any subject. Such sheets for work in subjects in the grades have been published by The Plymouth Press of Chicago.

We have also developed an entirely different method of checking the answers, which is wholly student performed, yet which does not reveal the correct answer until after the student has recorded his answer. This method will be described in a later article.

Following is a typical list of twenty questions. These are on the experiment which involves determining the weight of 22.4 liters of oxygen, Experiment No. 85 in Bradbury's manual.

1. Potassium chlorate, when heated, produces oxygen and potassium:
   —chlorite
   —chloride
   —and chlorine
2. Manganese dioxide, in this experiment:
   —is not permanently affected
   —loses oxygen
   —gains oxygen
3. Potassium chlorate contains approximately the following per cent of oxygen:
   —10
   —20
   —30
   —40
   —50
   —60
4. Standard pressure for measuring gases is that required to support a column of mercury, the length of which, in millimeters, is:
   —0.76
   —7.6
   —76
   —760
   —7600
5. Standard temperature for measuring gases is:
   —0′ C
   —0′ F
   —100′ C
   —100′ F
   —212′ F
   —212′ C

6. The weight of oxygen collected is:
   —increased
   —decreased
   —unaffected
   by the amount of manganese dioxide added.
7. The usual atmospheric pressure in our laboratory as compared to the standard pressure for measuring gases is:
   —higher
   —lower
   —the same
8. The weight of 22.4 liters of oxygen is an important constant because it is:
   —the basis for molecular weights
   —a convenient weight
   —easily determined
9. The weight in grams of 22.4 liters of carbon dioxide is:
   —32
   —16
   —12
   —28
   —44
   —40
10. The weight in grams of 22.4 liters of hydrogen chloride is:
   —1
   —35.5
   —2
   —71
   —36.5
   —73
11. The apparent volume of oxygen collected is:
   —increased
   —decreased
   —unaffected
   by the presence of water vapor.
12. The volume of oxygen collected is:
   —increased
   —decreased
   —unaffected
   by an increase in the temperature of the laboratory.
13. The volume of oxygen collected is:
   —increased
   —decreased
   —unaffected
   by an increase in atmospheric pressure in the laboratory.
14. The pressure of the water vapor in the bottle is dependent solely upon the:
   —temperature of the water
   —amount of the water
   —free surface of the water
15. As compared with that of the atmosphere, the pressure of the gas in the bottle as drawn is:
   —greater
   —less
   —the same




16. The solubility of oxygen in water is:
   —great
   —moderate
   —slight

17. The weight in grams of 22.4 liters of oxygen is:
    —8
    —12
    —16
    —24
    —32
    —36
18. The weight of 22.4 liters of oxygen, measured under standard conditions of temperature and pressure, determines its:
    —atomic weight
    —molecular weight
    —total weight
19. The number of cubic centimeters in a liter is:
    —1
    —10
    —100
    —1000
20. To subtract 1/14 of the volume, then 1/40 of the remainder, and then 1/19 of that remainder gives a result:
    —higher than
    —lower than
    —the same as
    if the corrections were made in a different order.

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## FOSSILS OF THREE-TOED HORSE FOUND IN OREGON.

The known range of the extinct three-toed horse in Oregon has been extended westward toward the Cascade lavas as the result of the recent discovery by W. S. Hodge of Redmon, Ore., of a number of fossil skulls in a hill near Gateway, Jefferson county, of a mammal identified as Merychippus isonesus, an animal about the size of a small pony. The identification was made by the late Dr. W. D. Matthew of the University of California.

Discovery of the Gateway locality with its numerous Merychippus remains is held significant by Dr. Edwin T. Hodge of the University of Oregon, who is making a detailed study of rocks and formations in the Deschutes valley. When doing field work in Trout creek, just north of the Gateway locality, several years ago, University of Oregon geologists discovered a new westerly exposure of the John Day sediments. Many fossils of Oreodons, creatures intermediate between a deer and a pig, were found. Further field work is to be done in the new Gateway locality this year.

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## DRUGS JELLY BRAIN AND NERVES.

Coagulation or clotting of the liquid protein substances of brain and sensory nerves is the cause of the action of common anaesthetic drugs. A challenge to the chemist is contained in this statement by Prof. W. D. Bancroft of Cornell University. Practically nothing is known about the nature or the properties of these animal proteins. Different proteins occur in different parts of the nervous system for suitable drugs can cause jellying of one region while leaving others untouched. Veronal causes reversible coagulation of the brain proteins without affecting the sensory nerves. Histamine coagulates the proteins of the sensory nerves. Curare causes partial clotting of the motor nerves, while potassium salts affect the proteins of muscle.—*Science Service.*

## OBJECTIVES OF SCIENCE TEACHING.

BY L. M. BERGEN AND OTHERS.

This paper reports a study made by a group of students in the University of Wisconsin during the summer session of 1930. The investigation was conducted in a course entitled "Investigations in the Teaching of Science" taught by Prof. Ira C. Davis.

The Committee[1] in direct charge of the investigation set for itself two main purposes:

1. To discover, classify, clarify, and define the general objectives of science teaching.

2. To determine, as far as possible, which objectives should receive the major emphasis in governing the choice of subject matter and method in teaching science.

Since the entire class contributed their assistance in collecting data and since the results are, at least in part, the result of their collective judgments, we give here a description of the personnel of the group as an essential factor in validating our findings.

The course was listed as a graduate course in Education. The 25 members of the class represented seven separate states. Twenty of them possessed Bachelor degrees, two possessed Master degrees, one was an undergraduate and two did not submit data. All but one had done some teaching—the median number of years taught being seven. All but one had taught science—the median number of years of science teaching being five years. All but two of the class had taught some science the previous year. The actual subjects taught during the previous year were as follows: 10 had taught Physics, 10 General Science, 9 Biology, 4 Chemistry, and one Nature Study. One of those who had not taught science during the previous year had taught Physiology and Physical Geography four years before the time of this study. Of those reporting, 18 were teaching in a Senior High School, 4 in a Junior High School, one in an Academy, one in the grades, and one was not teaching. Fifteen members of the class held the position of instructor and seven were principals. The median size of school in which the members were teaching was 450. It would seem evident from these data that the class was an experienced

[1]The Committee consisted of the following people: L. M. Bergen; F. C. Laun; P. J. Lunde; F. J. Mulder; G. G. Ricker; H. S. Rutherford, and C. R. Wolf.

group who were in the main teaching the sciences in the Senior High School.

PROCEDURE.

The first task was to obtain a reasonably exhaustive list of general objectives. In order to accomplish this the entire class was instructed during the first week of the course to gather, from whatever sources possible, lists of objectives in science teaching. A partial bibliography including books on the teaching of science, courses of study in science of the more progressive and larger cities, magazine articles, etc., was given to the class and they were asked to consult these, as well as textbooks, and any other sources they might find available.

From all of these sources each member of the class was asked to compile a list of objectives to be handed in at the end of the first week. These lists were then turned over to the committee to be classified.

The committee, after considering several methods of classification, decided to attempt to classify all objectives under the following categories: 1. Knowledge Objectives, 2. Power (Abilities), 3. Habit Objectives, 4. Appreciations, 5. Attitudes, 6. Purposes (drives), 7. Ideals (Emotionalized standards of conduct), 8. Interests.

The procedure of the committee was as follows: From all of the papers which the members of the class had written, one was selected which appeared to contain a fairly comprehensive list of objectives. Each of the objectives in this paper was read in turn and classified under one of the eight headings named above. The other papers were then taken and as each objective was read the committee first decided whether it was distinct from those already listed or was properly covered by them; and if distinct it was classified under the proper category. The entire committee passed judgment on the items read. In case of doubt as to whether the item was distinct or not it was included in the list. When this list was complete, the committee had sixty items which appeared to be distinct objectives in science teaching. This list[2], with changes to be noted later, appears in Table II.

[2]Since these lists were compiled from many sources it is extremely likely that many of these statements are direct quotations from books and magazine articles. Limitations of time did not permit the committee to check back on each statement and so we find ourselves unable to use quotation marks or give proper credit.

This list of sixty objectives was considered to be a tentative list only. The next step of the committee was to discover whether there had been any important objectives omitted from the list; whether they were all clearly understandable or needed defining; whether they were properly classified; etc. The assistance of the entire class was enlisted for this step also. The tentative list of objectives was mimeographed and each member of the class given a copy. Either on the mimeographed sheets or on separate paper the members of the class were asked to do the following things:

1. Suggest additional categories if they considered them necessary.

2. By checking with their original papers, suggest additional objectives if any appeared to be omitted.

3. Indicate clearly each objective:
   a. Which appeared to be incorrectly classified.
   b. Which appeared to be a duplicate of some other objective.
   c. Which did not seem to be clear and required defining or restating.

4. Suggest definitions or restatements for each item which did not seem clear.

The suggestions received from the class in this way were carefully reviewed by the Committee. Where these suggestions clearly indicated that changes were necessary the Committee revised the original list of objectives. The number of changes required was not great.

No additional objectives were suggested and no new categories were suggested. Two objectives were discarded. One was in the "Knowledge" category and read "Knowledge which is valuable as a preparation for life activities." The committee agreed with a large number of the members of the class that this type of knowledge was included in the other more specific objectives in this category. For a like reason an objective under "Appreciations" which read, "Appreciation of the true values of life," was omitted. It was felt that so far as science could contribute to these values the more specific items in this category would cover the point.

The other changes were more or less minor. Two

"Knowledge Objectives" were combined into one, and the wording of five other objectives was changed to make the meaning clear. The revised list of objectives appears in Table II. The original classification into eight categories is retained.

It might be noted at this point that in the original compilation, several of the objectives were defined or amplified by the committee so that there might be a measure of agreement on the meaning and implications of these objectives. For example the objective "Power or ability in the use of the scientific method" seemed to require definition and so the five steps listed by Good[3] as usually comprising the scientific method were added to the statement of this objective. "Habit of scientific thinking" and "Scientific Attitude" are other examples where definitions of this type were attempted. These will all be found in the complete list in Table II.

The committee now had a list of fifty-seven objectives for the teaching of science, each one of which appeared to be distinct from every other one and each apparently sufficiently clear to be entirely understandable to every member of the group. This completed the first part of the study.

### Determining Importance of Objectives.

The second part was designed to determine which objectives were considered by the class to be of greatest importance for the choice of subject matter and method in the teaching of science. Here again the judgment of the entire class was asked for. The procedure in this case was to hand each member of the class a mimeographed copy of the objectives, and request that the list be studied carefully with the idea of judging the objectives as to their relative importance for the choice of subject matter and method in science.

The next day each member of the class was given a pair of scissors and asked to cut up the mimeographed sheets so that a single objective would appear on a slip. Next they were to arrange these objectives in five groups in the order of their importance. The first group was to include those objectives which were thought to be of greatest im-

[3] "How to do Research in Education." Carter Good.

portance, the second group those of somewhat lesser importance than the first group, etc., until the fifth group was to include those which were considered to be of little or no importance for science teaching. This method of placing the objectives into groups was used because it seemed to offer a greater opportunity for the direct comparison of separate objectives and would consequently insure a more careful placement than a method where the rank was simply noted on the mimeographed sheets.

Each member of the class, when he had completed the grouping put the objectives in group one into an envelope, marked I and those for group II into an envelope marked II, etc.

These envelopes were collected and the contents dealt with by the committee in the following manner: All the envelopes marked I were emptied and one of the members of the committee read the objectives which had been classified in this first group while another member of the committee scored a one after the item on the original list. This same procedure was carried on for each of the succeeding groups; the only difference being that a 2 was scored after the item on the original list for each item appearing in the envelope II; 3 for those from envelope III; 4 for those from envelope IV; and 5 for those from envelope V.

When this tabulation was completed each objective should have had 25 scores—one for each member in the class who gave it a rank. Actually a few individuals failed to rank every objective so that some of them had fewer than the 25 scores. The arithmetical sum of these scores was obtained. Since the group of objectives which was considered most important was scored with a 1 and the least important with a 5 it follows that the objective receiving the lowest total score would have the highest rank. The only exceptions to this were in cases where an objective received less than 25 scores. In order to allow for this an average rank was obtained by dividing the total score by the number of scores which that objective received.

These quotients were, then, ranked, in order, from the lowest to the highest, the lowest representing the objective which this average rank indicated to be of greatest importance, the next lowest being next in importance, and so on until all were listed.

The objectives which received a rank of ten or better by this method, appear, in order, in Table I. It will be noted that in several cases two objectives received the same rank.

TABLE I—OBJECTIVES RECEIVING RANKS FROM 1 TO 10.

| Rank | Objectives |
|---|---|
| 1 | *Habit of scientific thinking. |
| 2 | *Scientific attitude. |
| 3 | Knowledge which will give an insight into the nature and organization of the environment making of it an organized whole instead of a lot of disjointed parts. |
| 3 | *Power or ability in the use of the scientific method. |
| 4 | *Appreciation of the Benefits of science. |
| 5 | Knowledge of scientific facts, principles, ideas, etc. (the structural materials of science.) |
| 6 | Desire for further knowledge. |
| 7 | Habit of Inquiry—looking for reasons and relations in the things about one. |
| 7 | Power to apply general principles to new and complicated facts. |
| 8 | Knowledge concerning appliances and principles which science has developed which are useful in making for greater comfort and convenience in home and community. |
| 9 | Knowledge which will satisfy natural interests in the forces of nature with which we are surrounded, and with which we must deal. |
| 10 | *Appreciation of the universal operation of natural law. (Cause and effect relationship.) |

*The objectives marked with the asterisk are more fully defined in Table II.

Table II contains the entire list of objectives with their ranking.

This is the list after the corrections noted above had been made. It is the list which the class actually ranked. The original classification into eight categories has been retained, but the order has been changed to correspond with the ranks, so that in this table the objective which received the highest rank in its category appears first, the one receiving next highest rank second, etc. The explanation of the five columns of data is as follows:

Column (T) contains the arithmetical total of the scores for each objective as explained above.

Column (F) gives the frequency—number of people who ranked the objective.

Column (Q) gives the quotient obtained by dividing the total of the scores by the frequency.

Column (R) gives the rank of the objective as determined by these quotients. These ranks are in comparison with the entire list regardless of category.

Column (R. C.) gives the rank of each objective within its category. The objectives have been re-arranged so that the order within the category now corresponds with these rankings.

The table should be read as follows: "Knowledge which will give an insight into the nature and organization of the environment," etc. (the first objective in the "Knowledge" category) received a total score of 41; was ranked by 25 people; the average score was 1.64 (41÷25); which was the third lowest score of all the 57 objectives, and so gave this objective a rank of 3; this was the lowest average score in the "Knowledge" category so giving this objective a rank of 1 within its category.

TABLE II—OBJECTIVES OF SCIENCE TEACHING WITH THEIR RANK.

| OBJECTIVES | T | F | Q | R | R. C. |
|---|---|---|---|---|---|
| I. *Knowledge Objectives.* | | | | | |
| 1. Knowledge which will give an insight into the nature and organization of the environment, making of it an organized whole instead of a lot of disjointed parts | 41 | 25 | 1.64 | 3 | 1 |
| 2. Knowledge of scientific facts, principles, ideas, etc. (The structural materials of Science) | 43 | 24 | 1.79 | 5 | 2 |
| 3. Knowledge concerning appliances and principles which science has developed which are useful in making for greater comfort and convenience in home and community | 47 | 24 | 1.95 | 8 | 3 |
| 4. Knowledge which will satisfy natural interests in the forces of nature with which we are surrounded and with which we must deal | 50 | 25 | 2.00 | 9 | 4 |
| 5. Knowledge of the nature, requirements and possibilities of the vocations built on science, for the purpose of assisting in the choice of a vocation | 61 | 25 | 2.44 | 14 | 5 |
| 6. Knowledge of common scientific terms which occur in reading | 64 | 25 | 2.56 | 18 | 6 |
| 7. Knowledge of the experimental evidence for some of the fundamental principles of science | 63 | 24 | 2.62 | 19 | 7 |
| 8. Knowledge of science which will directly prepare for further work in science and the vocations built on science. (Valid only for those who have chosen a vocation) | 69 | 25 | 2.76 | 21 | 8 |
| a. Semi-skilled vocations. | | | | | |
| b. Professions—Engineering, Medicine, etc. | | | | | |
| II. *Powers. (Abilities.)* | | | | | |
| 1. Power or ability in use of scientific method. This power may be analyzed into: (after Good, p. 77) | 41 | 25 | 1.64 | 3 | 1 |
| a. Formulation and definition of problem. | | | | | |

| OBJECTIVES | T | F | Q | R | R. C. |
|---|---|---|---|---|---|
| b. Collection and assembly of necessary and relevant data. | | | | | |
| c. Critical analysis of data. | | | | | |
| d. Development and formulation of hypothesis of possible solutions. | | | | | |
| e. Testing the validity of proposed hypothesis until a satisfactory solution is found. | | | | | |
| 2. Power to apply general principles to new and complicated cases | 48 | 25 | 1.92 | 7 | 2 |
| 3. Power or ability to generalize rationally from experimental results | 63 | 24 | 2.63 | 20 | 3 |
| 4. Power or ability in the use of laboratory technique and its application to objective materials | 73 | 24 | 2.92 | 24 | 4 |
| 5. Power or ability to exercise and control one's imagination | 89 | 25 | 3.56 | 36 | 5 |
| III. *Habit Objectives.* | | | | | |
| 1. Habit of scientific thinking | 34 | 25 | 1.36 | 1 | 1 |
| a. See problems. | | | | | |
| b. Define them clearly. | | | | | |
| c. Collect necessary data. | | | | | |
| d. Make a guess at the solution. | | | | | |
| e. Prove or disprove by experiment or observation. | | | | | |
| f. Arrive at correct solution. | | | | | |
| 2. Habit of inquiry—looking for the reasons and relations in the things about one | 48 | 25 | 1.92 | 7 | 2 |
| 3. Habits which make for healthful living | 52 | 24 | 2.16 | 19 | 3 |
| 4. Initiative | 54 | 24 | 2.25 | 11 | 4 |
| 4. Keenness of observation | 54 | 24 | 2.25 | 11 | 4 |
| 4. Accuracy | 54 | 25 | 2.25 | 11 | 4 |
| 5. Independence of thought and action | 58 | 25 | 2.32 | 12 | 5 |
| 5. Habit of carrying conclusions over into actions | 58 | 25 | 2.32 | 12 | 5 |
| 6. Carefulness | 67 | 23 | 2.91 | 23 | 6 |
| 7. Persistence | 77 | 25 | 3.08 | 27 | 7 |
| 8. Self control | 77 | 23 | 3.21 | 30 | 8 |
| 9. Habit of system and order | 83 | 25 | 3.32 | 31 | 9 |
| 10. Habit of lucid expression | 77 | 22 | 3.34 | 32 | 10 |
| 11. Aggressiveness | 82 | 24 | 3.41 | 33 | 11 |
| 12. Neatness | 76 | 22 | 3.45 | 35 | 12 |
| 12. Habit of considering others | 83 | 24 | 3.45 | 35 | 12 |
| 13. Regularity | 87 | 24 | 3.62 | 37 | 13 |
| 14. Patience | 89 | 24 | 3.70 | 38 | 14 |
| IV. *Appreciations.* | | | | | |
| 1. Appreciation of the benefits of science in | 40 | 24 | 1.66 | 4 | 1 |
| a. Freeing people from disease. | | | | | |
| b. Producing comforts and conveniences. | | | | | |
| c. Producing and sustaining the modern industrial system. | | | | | |
| 2. Appreciation of universal operation of natural laws (cause and effect relationship), resulting in: | 54 | 25 | 2.16 | 10 | 2 |
| a. Freedom from haunting fears and appalling superstitions. | | | | | |
| b. Freedom from ignorant practices. | | | | | |
| 3. Appreciation of the marvels underlying our commonplace environment | 54 | 25 | 2.36 | 13 | 3 |

| OBJECTIVES | T | F | Q | R | R. C. |
|---|---|---|---|---|---|
| 4. Appreciation of beauty in nature and natural phenomena | 65 | 22 | 2.50 | 16 | 4 |
| 5. Appreciation of the work of great scientists, past and present | 76 | 25 | 3.04 | 26 | 5 |
| 6. Appreciation of the work of scientific research | 75 | 22 | 3.41 | 33 | 6 |
| V. *Attitudes.* | | | | | |
| 1. Scientific Attitude: For purposes of this paper this will mean that one possessed of the scientific attitude will exhibit the following characteristic: | 37 | 25 | 1.48 | 2 | 1 |
| a. Open mindedness—withholds judgment until all the facts are known. | | | | | |
| b. Places confidence in objective evidence rather than authority or opinion. | | | | | |
| c. Fairmindedness — seeks the whole truth regardless of personal bias, social or religious prejudice. | | | | | |
| d. Intellectual honesty—refrains from overstatement but adheres to scientifically accurate statements and opinions. | | | | | |
| 2. Attitude of confidence in the results of science | 76 | 25 | 3.04 | 26 | 2 |
| VI. *Purposes* (*Drives*). | | | | | |
| 1. Desire for further knowledge | 46 | 25 | 1.84 | 6 | 1 |
| 2. Zest for verification | 59 | 24 | 2.46 | 15 | 2 |
| 3. Desire for facts rather than opinions | 63 | 22 | 1.50 | 17 | 3 |
| 4. The "Will to experiment" in settling problems | 71 | 23 | 3.09 | 28 | 4 |
| 5. Spirit of Invention | 87 | 23 | 3.78 | 39 | 5 |
| VII. *Ideals* (*Emotionalized Standards of Conduct*). | | | | | |
| 1. Persistency | 71 | 25 | 2.84 | 22 | 1 |
| 2. Loyalty to truth | 75 | 25 | 3.00 | 25 | 2 |
| 3. Service | 71 | 23 | 3.09 | 28 | 3 |
| 4. Devotion to cause | 79 | 25 | 3.16 | 29 | 4 |
| 5. Tolerance | 79 | 23 | 3.43 | 34 | 5 |
| 6. Self-sacrifice | 70 | 22 | 3.45 | 35 | 6 |
| 7. Altruism | 93 | 24 | 3.88 | 40 | 7 |
| 8. Kindness . . . | 90 | 23 | 3.91 | 41 | 8 |
| 9. Sympathy | 91 | 23 | 3.95 | 42 | 9 |
| 10. Humaneness | 94 | 23 | 4.08 | 43 | 10 |
| VIII. *Interests.* | | | | | |
| 1. Acquirement of interests which may develop into vocational or avocational activities | 58 | 25 | 2.32 | 12 | 1 |
| 2. Acquirement of a dominating interest in field for which he is best fitted | 71 | 25 | 2.84 | 22 | 2 |
| 3. Interests in science articles in newspapers and magazines | 76 | 25 | 3.04 | 26 | 3 |

## SUMMARY AND CONCLUSIONS.

1. The data in this study was secured from a group of 25 graduate students who had a median of five years' experience in science teaching.

2. A list of fifty-seven distinct objectives for science

teaching was secured and these were classified into eight separate categories.

3. In ranking the objectives the members of the class appeared to place more importance on scientific thinking, attitudes, etc., than on specific knowledge. Four of the first five ranks were given to these non-knowledge objectives.

4. The kind of knowledge which seemed to be of first importance was that which would give an insight into the nature and organization of the environment. This received third ranking, while knowledge of useful scientific appliances was eighth.

5. The committee feels that the number of people ranking the items is too small to permit of placing great weight on the exact position of any item in the list, although the general trend may not be without significance. Perhaps the chief values of the study may lie in the listing of a large number of specific objectives, and in the methods developed for defining, classifying, and ranking the objectives.

The same list, if ranked by a larger sampling of science teachers, would establish with greater certainty the relative importance of these objectives in the eyes of science teachers.

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## CAMBOSCO SCIENTIFIC COMPANY.

A new name appears in the list of approved apparatus and supply houses. It is not the name of a new company but a new name for an old and reliable house. The change in name is symbolical of the expansion of the company's business. The Cambridge Botanical Supply Company has become Cambosco Scientific Company, headquarters for all kinds of scientific apparatus and supplies. There has been no change in ownership, policy or directing personnel.

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## ELECTRONS AND PROTONS PAIRED IN ATOM NUCLEUS.

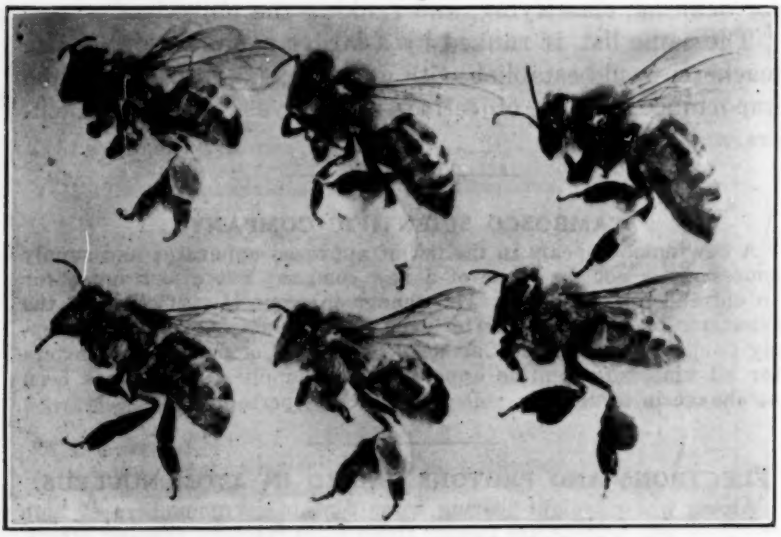
Atoms whose weight-bearing cores contain even numbers of both electrons and protons are twenty times more frequent than all others, Prof. William D. Harkins of the University of Chicago, reported to the American Chemical Society. Of all the chemical elements found on the earth, 95 per cent. belong to a class in which each building stone of the atomic core has a mate. The electrons of a pair in the central heart of the atom are not absolutely identical, however. One is spinning in the opposite sense to the other. Thus the nucleus as a whole is free from spin. These facts throw very important light on the stability of atoms and therefore on the reason why some chemical elements, like radium, are continuously disintegrating into simpler atoms.—*Science Service.*

## SOME LESSONS ABOUT BEES.

By T. P. Webster, M. A.,
*Allegheny Vocational School, N. S. Pittsburgh, Pa.*

### Lesson II—The Bee As An Expert in Transportation.

Ten thousand bees may carry one pound of nectar in the honey crop or sac at one time, but one pound of nectar would be more like a normal load for 20,000 bees. Nectar is sweetened water which the bee gets from the flower. It is a *raw product*. One of the great factors in production of goods is transportation of raw materials. This nectar has so much water in it, which must be evaporated, that four pounds of nectar must be brought in for every pound of honey stored. This means four times 20,000 bee loads or 80,000 bee loads for each pound of honey. A bee normally travels a mile and a half for each load. This means transportation of nectar totaling 120,000 miles or more than four times the distance around the globe.



Pollen and Nectar Ladened Bees On the Wing. The Pollen Pellets Are on the Hind Legs. Nectar Is Carried in the Honey Sac Inside the Bees' Body.

An investigator found great variation in the average time consumed in these flights. The shortest flights averaged 8.92 minutes and the longest 103.92 minutes. On days when nectar was scarce the flights were long in duration. The early morning trips were short, the midday trips long and

the evening trips short. The short trips were thought to be water carrying trips.

At this point it is well to consider the adhesive organ of the foot. The bee carries a non-skid or safety device between and below the bases of its two claws. It consists of a stalk and a soft bilobed appendage. Whenever the nature of the support prevents the claws from taking hold, they turn helplessly forward and outward and cause pressure to be exerted on a liquid filled cavity which drives the liquid into the lobes. The lobes expand and a part of the liquid exudes through certain hairs and enables the lobes to adhere to the surface. All this may be best observed in a bee walking on a glass, but Nature designed this device to enable the worker to cling to smooth petals of certain flowers. This organ is of much practical importance to our expert producer, the bee.

### LESSON III—STORING THE RAW PRODUCT.

The nectar laden bee on return from the field is not in a hurry to get rid of her load. She may keep it a half hour or more before depositing it. She enters the cell with her back down and feet up. If the cell has no honey in it, she goes in until her mandibles touch the upper and rearmost angle. The mouth and mandibles are opened and a drop of nectar appears, welling up till it touches the cell wall. Slowly the bee turns her head from side to side, spreading the nectar against the upper part of the cell. All this time the mandibles are kept in motion and as the nectar covers their gland openings, it is possible that the secretion of those glands is being added to the nectar.

When the bee is adding her load to honey already in a cell, the proceeding is the same, except that the mouth parts are

A HONEY COMB FROM THE BROOD NEST OF A BEE HIVE WHERE THE BEES STORE HONEY AND POLLEN AND REAR YOUNG.

submerged in the honey already there. The mandibles are kept in motion as before. The tongue in neither case takes any part in the proceeding, but is kept folded behind the head.

## LESSON IV—THE BEE REFINING RAW PRODUCTS.

### *Ripening Honey.*

Evaporation and conversion of the thin nectar into thick honey is called ripening.

After the day's work is about over, almost all the bees in the hive spread out over all available surface and nearly every bee has her sac full of honey. All the bees hang vertically with head up and all seem to prefer not to be crowded too closely by the other bees. Then each bee opens her mandibles and mouth and forces up a drop of nectar. This drop fills the mouth and extends up over the upper lip and fills the space between the mandibles, covering the openings of the glands. The bee next begins a chewing motion with the lower jaw and this causes the drop to pulsate. The mandibles are held still. They are not moved as in depositing nectar. For about ten minutes this operation is continued, then the drop is swallowed, and after a few moments' pause another drop appears, and the process is renewed. This is often continued by the colony until about 11 p. m. or sometimes later, and then the work stops and all hands go to sleep.

In this work modification of nectar has been accomplished. When the honey has been thoroughly modified in the bees' honey stomach it is ready to be capped over. Uncapped combs of honey taken from the hive have poor keeping qualities. Analyses of honey have revealed nine kinds of acids present. Two digestive enzymes, invertase and diastase, are present in all honeys. In a word honey is a sugar which has gone through one stage of digestion in the bee. It is a *standard* product now. Honey in one cell is just as good as honey in another. A trademark is unnecessary as a guarantee of quality. It is estimated that the annual production of honey in the United States is between 200 and 300 million pounds.

In hot weather a number of bees in every hive act in the capacity of electric fans. They must have ventilation in order to evaporate the water from the thin nectar. This

ventilation also serves to keep the temperature of the hive below the melting point of beeswax. Beeswax, though it has the highest melting point for its ductility of any wax known, in very hot weather sometimes melts in the hive from the heat of the sun.

On front of any hive on a hot day their heads pointing toward the entrance may be seen a part of the ventilating squad. These bees are drawing the foul air out of the hive. On the inside of the hive their heads also toward the entrance is another file of bees propelling the air past them into the hive. Here is a double ventilating system based on good mechanical principles.

Building engineers who specialize on the ventilating of theaters (our nearest approach to a hive) recently announced that there is a vivifying influence imparted to air simply by keeping it in motion. This vivifying influence is independent of any new supply of oxygen. Inside the hive are other detachments agitating the air.

A bee has two pairs of wings placed so close together that their edges almost touch. The wings are hooked together in flying and for this purpose there is a row of hooks on the forward edge of the rear wing and a stiff pleat on the edge of the front wing which the hooks easily engage. A single pair of wings such as the fly possesses would be quite as serviceable in flying, but such a pair would not go into a bee cell. For this purpose they unhook and fold together like a fan. It has been observed that in ventilating the bees do not have the wings hooked together.

Though we are considering ventilation as a means of ripening honey it might be well to relate here how the bees have been known to rise to the emergency of a lumber yard fire near their home. In Medina, Ohio, a few bee hives were located near some big lumber piles that were burned down. One of these hives took fire and burned through one side. The bees were all right after the fire. It is presumed that some firemen seeing the plight of the bees, threw on a pail of water; but how did the bees keep the combs from melting down in the meantime? There was no other way that they could do it than by their scheme of ventilation. Fortunately the entrance was large and wide open, so they were able to ventilate the hive fully; also the weather outside was cold. Even though combs sometimes melt down

when the weather is very sultry and hot during the summer they did not melt in this hive during the fire. The air was cold on this night and the entrance was away from the direct radiation of heat from the burning lumber.

Bees in active motion have a temperature slightly above that of the air even though they liberate a large amount of heat generated by muscular action. In winter bees with an abundance of stored honey are able by wing movements to generate sufficient heat to keep the temperature of the center of the bee cluster between 57° and 97° F.

*Secreting Wax.*

Wax with which the bees build the honey comb is made in the bee's body. When there is comb to be built the young bees will gorge themselves with honey and then hang themselves up in festoons in the more quiet recesses of the hive.

A Bee Secreting Wax Scales. Eight Wax Scales Are to Be Seen Protruding from Between the Segments of the Bee's Body.

In about 24 hours little pearly discs of wax somewhat resembling fish scales protrude from between the rings on the under side of the bee's body. Sometimes these scales come so fast that they fall on the bottom of the hive and may be scraped up.

Sometimes the bees remove these scales by piercing the scale or catching into it by means of spines protruding from

the planta section of the hind legs. The engaged scale is moved up to a place where the front legs may grasp it when it is transferred to the mandibles where it is thoroughly masticated. The bee seems to moisten the wax with saliva before she fastens it to the wood of the hive or the wax combs. The temperature of the hive being in the neighborhood of 98° Farenheit during wax building activities, the wax is soft and pliable and easily fastened to the growing edge of the cell by the blunt mandibles of the bee's mouth. It is estimated that three to six million pounds of wax are produced yearly in the United States.

*Preparation of Nursery Food.*

The food given to the young honey-bee larva in the comb cell is a gummy paste of milky white color when fresh. It is very acid, acrid, and pungent to the taste. This food is placed in the larval cell at about the time the egg hatches. The queen larva is fed this royal jelly exclusively during the whole of its lifetime. The worker and drone larva have pollen and honey added to their diet the third day and thereafter are fed largely on these substances.

After pollen has been deposited in a cell by the fielder who carried it in, another bee comes along and mashes the lump of pollen and packs it securely into the bottom of the cell or into the mass of pollen already present. Probably this bee adds more honey and more saliva to the stored pollen which changes the latter finally into "bee bread." It is this kind of modified pollen which together with honey makes up the food of the young workers and drones.

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**COSMIC RAYS AS ATOM BUILDING SIGNALS QUESTIONED.**

Not enough atom-forming collisions occur in the depths of space to account for the intensity of penetrating cosmic radiation observed here on the earth, Dr. L. S. Kassel, of the U. S. Bureau of Mines at Pittsburgh, told the Americal Chemical Society.

The theory of Dr. R. A. Millikan and Dr. G. H. Cameron of the California Institute of Technology that atom-building is the cause of the ultra-X-radiation that streams down into the earth's atmosphere from above, would require that in the formation of an iron atom, for instance, 28 electrons and 56 protons or hydrogen atom cores would need to meet at the right time.

Dr. Kassel asserted that collisions occur ten million billion times too seldom for this. His calculation, however, is based only on the building of iron atoms, one of the many kinds of atoms which may give rise to penetrating rays, during their formation.—*Science Service.*

## FURTHER OBSERVATIONS ON ANIMAL COLLECTIONS.

By FRED R. CLARK,
*Southeastern Teachers College, Durant, Okla.*

In a recent number of SCHOOL SCIENCE AND MATHEMATICS[1] the writer mentioned a way in which he believed that classroom and laboratory work in Animal Biology could be rendered more vital through the use of animal collections made by the individual students of the class.

Now there are some objections to the making of collections by students. For one thing they might be bitten by some of the animals they collect or worse yet get mixed up with poisonous reptiles, centipedes, scorpions or the like. Such circumstances would undoubtedly tend to give the course in Biology a black eye and no teacher wants that! It is of course possible to give suitable lectures to the students beforehand about these dangerous animals but this will not remove all danger as there are always some students who allow what is said to go in one ear and out the other.

Another point against collections is the cost of materials needed for preserving specimens. Jars, bottles, stoppers, chloroform, formaldehyde, alcohol, labels and what not, run up into real money either for the student if he buys his supplies or the department if it furnishes them.

Finally, to look over the specimens collected, to identify and check up, takes an immense amount of the teacher's time, often when he is the busiest. There is also considerable physical work entailed in lugging around big boxes of jars, throwing out discarded material and so forth. The laboratory may become fairly saturated with formaldehyde and chloroform fumes by the time everything is completed.

These are the disadvantages of such a collection—the advantages are many as has been mentioned in other papers by the writer on the subject. It has seemed to the writer that some teachers might wish to keep to the advantages accruing from such a collection and at the same time wish to avoid the disagreeable features above mentioned.

There are one or two ways of doing this. During the past term here the students have been required to hand in a set of cards bearing observations on animals which they

[1]School Science and Mathematics, November, 1930.

have made in the out of doors. It is desirable that a uniform series of cards of some convenient size be used for this purpose. The student is given beforehand a definite set of requirements as to what kind or type of animals he is to observe and how many—much the same as described in the other papers on collections. Then he is also furnished with a set form which he is to use on his cards and fill out with his own observations from animals seen. This form should be as full as possible and can be varied to suit the pleasure of the teacher. The form that I have used follows. This form will naturally not fit all types of animal life, nor is it claimed that it is perfect. Doubtless the reader will find mistakes and can improve it considerably.

FORM FOR ANIMAL COLLECTIONS OR OBSERVATIONS.

1. Name in English:
2. Name in Latin:
3. Phylum:
4. Additional Classification:
5. Dates Observed:
6. Where Seen:
7. Habitat:
8. Its home:
9. Reproduction:
10. Care of Young:
11. Does it Migrate? Hibernate?
12. How common is the animal?
13. Food:
14. Economic importance:
15. Intelligence:
16. Defense:
17. Offence:
18. Enemies:
19. Locomotion:
20. Activity:
21. Emotions:
22. Social conditions:
23. Mating habits:
24. Size:
25. Sex:
26. Voice or song:
27. For what purpose does it give voice?
28. Shape:
29. Appendages:
30. Head:
31. Method of breathing:
32. Neck:
33. Body color and markings:
34. Body covering:
35. Color of male:
36. Color of female:
37. Teeth or jaws:
38. Eyes:
39. Ears:
40. Mouth:
41. Hoofs:
42. Horns:
43. Nails:
44. Claws:
45. Tail:
46. Other characteristics:

Another way in which the student can be made to observe nature is by the compilation of a book of pictures instead of cards. Proceed in the same way that you do for the cards or collection. Assign types, phyla and numbers of animals to collect. Then require that the student make a collection of pictures of these animals all properly labeled with scientific and English names, phylum or other group, date taken, when taken, habitat, and so forth. It is immaterial how these pictures are made as long as the student makes them himself. They may be accurately drawn and

colored, they may be in pen and ink, water color or oil could be used if the student were skillful enough, or photographs could be taken. This last might sound easy but try to photograph thirty or forty animals of all sizes, colors and shapes and you will see that there are difficulties. Cost is also an item with photographs. Personally I believe in giving the student a chance to work in the medium with which he has the most skill providing it is of equal difficulty with the others. Some may wish to combine various kinds of pictures and I see no objection to that. All pictures when completed can be neatly bound in a book with a cover to be handed in.

The writer makes use of some sort of out of doors work in his Biology classes. Collections have been used, field trips, projects of all sorts and cards and pictures. All have value. All have advantages and disadvantages. It is often wise to alternate one type of observation with another the following term as it stops cheating and use of old material from the class before.

In one of the recently republished books by David Star Jordan[2] he has this to say: "The study of Biology as a whole has, however, this disadvantage in the scheme of training: it is prone to give 'information without contact,' one of the banes of education. By giving broader views, the intensity of personal observation and induction is dimmed and the charm of outdoor research is lost."

The writer believes that collections or observations by students will serve to obviate this glaring deficiency of our modern Animal Biology laboratory.

[2]Jordan: Manual of Vertebrate Animals, 13 ed., 1929, World Book Co., N. Y.

## JEWELL EDUCATIONAL CHARTS.

The Jewell Electrical Instrument Company has recently published three interesting educational charts showing the principles of design and processes of manufacture of direct current D'Arsonval Movements, alternating current Iron Vane Movements and Dynamometer Movements for wattmeters.

These charts, with diagrams in three colors, are printed on wall charts measuring 21½" x 27½". They are available without charge to heads of science departments of secondary schools and colleges who will address the Jewell Electrical Instrument Company, 1650 Walnut Street, Chicago, Ill., making their request on the official stationery of the department and signed by the head of the department. To all others these charts are available at $1.00 each.

## SOME COMMENTS FROM SCIENCE INSTRUCTORS AND OTHERS.

BY A. C. MONAHAN,

*Formerly U. S. Bureau of Education.*

The series of articles, prepared by the writer and running in SCHOOL SCIENCE AND MATHEMATICS during the present year, have brought in a considerable number of letters of comment many of which contain statements that should be passed on to the readers of the Journal. Space will permit the printing of selections from only a few. It is due to those who are quoted to say that their letters were not prepared by them for publication, and I am not asking their permission, feeling that their interest in the promotion of science teaching is so great that they will be glad to have their ideas used where they can be of help.

A number of instructors have expressed themselves as believing that the decreasing percentage of enrollment in the high school science classes is due largely to themselves and their work. Miss Estella G. Pearce, Biology instructor in the Ludington (Mich.) High School, after a study of the situation in her own school and in others says:

"I think among the greatest detriments to the science courses, are the science teachers themselves. We have failed to popularize our subjects by making them fit the daily life and interests of the pupil. We are too inclined to make the memorizing of facts the ultimate objective. Personal experimentation and investigation should be the key word of the science courses."

Mr. E. Clarke Fontaine, State supervisor of High Schools for Maryland, has had an opportunity to study the situation during several years in which he has spent his entire time visiting schools. His criticism has to do with the lack of ability on part of the science teacher to get away from college science methods and adopt methods suitable to high school ages. He states:

"The most serious obstacle in the way of making our high school courses in science 'vital, practical and interesting' as I see the situation, resides in the fact that the college teaching of science is so widely divergent from the modern point of view of science instruction in the secondary school that it usually takes us in Maryland from one to two years to eliminate 'college science' or 'college preparatory science' from the high school teacher's mental background. By that time so many of our science teachers have changed their location or quit teaching that we have to start all over again with a new group."

Mr. F. E. Fowlkes, assistant principal of the John Marshall High School of Richmond, Va., and president of the science section of the State Teachers Association, senses the need of better teaching of sciences in the State if the science departments are to gain and hold the prestige that they should have, and feels that the solution is in the hands of the science teachers themselves.

"At our science meeting at the State Association meeting, we decided to carry out a prolonged study of science instruction in the State of Virginia during the coming year. We realize a need for better coordination and improved teaching which would undoubtedly aid in the type of work now being done."

Dr. C. M. Pruitt, of the faculty of the University of Alabama, himself engaged in the preparation of teachers for science work in high schools, feels that the colleges and universities training high school teachers do not give proper attention to those who are to be instructors in science work. He is of the opinion that they do not give enough science to properly qualify them for teaching the science subjects. He writes:

"The statistics are of value as they serve as a pilot to school officials, curriculum makers, etc., in that they show that there are four major sciences taught in high schools. There is little use for candidates for teaching to prepare for teaching one of the other sciences outside these four and expect a job. Also candidates for science teaching know that they will be required to teach from one to four of these major science subjects. Teachers are not doing what they might to require colleges to give more science courses to prospective teachers. They know that they are inadequately trained and yet few of them demand that the colleges give more and better courses in science. For example, a major in science in Alabama has to have only 24 hours in all sciences, distributed as he sees fit. He goes out to teach Physics, Chemistry, Biology, and General Science, perhaps without ever having had a college course in one or two of these four subjects. However a science teacher has never complained to me about the lack of opportunity presented to him in college to take the subjects that the college instructor knew he would have to teach as a high school science teacher, unless I raised the question first."

"I am trying to get a better science requirement here at the University of Alabama for science majors, at least 32 hours and properly distributed. It is a hard job even to convince leaders in education of the need."

Other letters as well as that of Dr. Pruitt carry the statement that the colleges are not giving enough work in the sciences to candidates for high school teaching. Others state that the college science courses contain too much mathematics and thus influence the young teacher to make his high school teaching include more mathematics than should be included. This makes his course

difficult for many who are interested in science as a cultural subject and an informational subject, and are not interested in the mathematical theories behind them. The reputation of being too mathematical undoubtedly has kept many pupils from enrolling in the physical sciences who would have enrolled otherwise. This is true in college courses as well as in high school courses and has lead some colleges to offer a special "informational" physics course for students who desire science knowledge without the mathematics.

Mr. Maynard Shipley, president of the Science League of America, says on this subject in a letter to the writer:

"The statement that much of the mathematics of the physics and chemistry courses 'could well be omitted except for those students who are going on to college' is eminently true and should be more generally acknowledged. Even if he does intend to go to college, much of the mathematics now required should be omitted unless he intends to continue to study physics and chemistry there."

While apparently agreeing that many high school physical science courses are too mathematical, Mr. Walter D. Albert of the faculty of the State Teachers College at Wayne, Nebraska, is of the opinion that college students in these subjects, preparing to teach them in high schools, should themselves have special training in mathematics. He does not maintain that the mathematics be given in the physics or chemistry courses, but as separate courses. He says:

"Teachers of science, especially of the physical sciences, must have at least a major in mathematics to be qualified, in my opinion. Another factor that causes some difficulty is the inability of pupils with even three years of mathematics to handle efficiently the verbal problems in physics. Pupils are easily lost if the teacher is not alert in almost any problem involving algebra. Perhaps one should say our mathematics courses should be taught so as to fit them with a 'clutch' to connect them with situations to be met in problems later.

"Pupils opinions are helpful. My pupils tell me that they like physics better than any other course they are taking or ever have taken. They also say they do more real learning in physics than in any other course. They are particularly interested in all practical connections that we can point out. They work in laboratory alone or in groups of from two to four persons and they thoroughly enjoy the work."

Mr. Albert states elsewhere that in the smaller schools in Nebraska many teachers are conducting the science courses because there is "no one else who is even partly prepared to take them." In many of these schools there is little equipment for teaching sciences because of the

"rigid economy" practiced by the school authorities. Dr. John N. Swan formerly head of the Chemistry Department of the University of Mississippi, speaking of this "rigid economy" is of the opinion that high school teachers would have more apparatus in these poorly equipped schools if they would put up more of a fight for it. "So many of them just give up trying to get money for their work."

The practicability of advertising their departments seems to appeal to some. Miss Helen Field Watson, Biology instructor in the senior high school at Mitchell, So. Dakota, writes:

"While wishing to make general conclusions about the matters of cost and recognition, my inclination is to apply these articles to my own experiences. But this tendency on my part suggests that this will be the inclination of all who read the articles.

"We have felt in our senior high school the decrease in enrollment in Physics classes in the last few years, and the increase in General Science in the junior high school. But since the number in Chemistry is practically stationary because the possible enrollment is limited to four sections of 24 each, we have not met any problem there. The same is true of Biology. Hence we have scarcely sensed a general decrease in interest in these fields.

"The publicity methods which you suggest seem practical and justifiable. The success of athletics certainly depends upon advertising. I find that an attractive laboratory, with plants, good pictures, 'live stock', interesting bulletin boards, evidences of field trips, attract many upper classmen into the room. The most effective advertising seems to be what the biology students tell their friends.

"Since reading your articles I feel eager to do more advertising, even if we have more applying each year than can take the course."

Another science instructor, who asked that his name be not used if his letter was quoted, says in effect the science teacher should take every legitimate step to let the pupils of the school know the real worth of the science courses. "I have found that auditorium-demonstration-lectures, before the entire school, have been very well received and have attracted much attention to the science department. However I use many other plans for keeping the courses we offer before the school."

Frank W. Hanson, Head of Science Department, Wilby High School, Waterbury, Conn., believes that many teachers are not successful because they fail to impress their pupils with their own belief in the importance of the subjects they are teaching:

"Not one of us would appear 'dead' in the classroom, but unless we have a great love for the sciences and a keen feeling that science

is intimately connected with the life of the pupil we will appear dead to those in our classes. So if you would create and continue interest in your science courses be inspirational by getting frequently inspired."

Dr. H. A. Webb, of Peabody College, Nashville, Tenn., touches on the same subject. The lack of inspiration in the subject on the part of the teacher often is responsible for "text-book" courses unsupported by laboratory work with materials. He writes:

"The procuring, arrangement, and care of objective materials ought to be just as scientific as the presentation of topics. How much study there has been on how to present thought material to young people in comparison to the attention paid on how to select objects for them to handle. We must never forget the old maxims concerning the training of the mind, the hand, and the heart together.

"I am not sure but that the arrangements for objective experience are not at times more difficult than the arrangements for vicarious experience. How many science teachers, indeed, find it too much trouble to work with things, but easy to use books and encyclopedias! Of course we need the books, but not to the exclusion of objects."

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## A GENERAL LESSON PLAN IN SCIENCE.

By IRVING FINE,

*The James Monroe High School, New York City.*

The following is a summary of a highly successful lesson plan used by the author in teaching science at the James Monroe High School.

Although this outline has been designed for the standard forty minute recitation period, still it is flexible enough to be modified for use during periods of other lengths. Furthermore, inasmuch as the plan is so general in its scope, it is equally well adapted for use in the teaching of academic subjects.

1. Before the ringing of the beginning bell papers are distributed for the daily short written quiz. At the sound of the bell, one or two questions are dictated on the previous day's classroom work. The test takes but three minutes and has a fourfold purpose, namely: 1—It secures promptness in arriving at class and no time is wasted in getting started; 2—It serves as a valuable stimulus for daily preparation; 3—It acts as a review; and 4—It allows the teacher time to attend to routine matters—taking the roll, glancing over the lesson plan, etc.

2. About four minutes are then spent in discussing the test.

3. Homework books are then opened and question cards are distributed for the blackboard work. During the three minutes used at the boards, the teacher checks up on the day's homework.

Thus far, although but ten minutes have passed, 100% pupil participation has already been obtained.

4. The next twenty minutes are then utilized in a discussion of the board-work.

In the writer's experience, it has been found that upon returning to their seats, those who were at the blackboard pay very little attention to what is going on in class. It seems, that inasmuch as the board-workers are ordinarily merely expected to recite upon their own particular written work, their minds are naturally completely occupied in devising means for producing the most effective recitation. In order to obviate this undesirable situation, the following plan has been used with much success:——The pupils who write at the board are not expected to recite upon their own individual work. Instead, those who remain at their seats are given the opportunity to read the board work aloud. They then critically analyze and discuss the answer and comment upon its accuracy. It is understood, of course, that this procedure does not exempt the board workers from reciting upon another pupil's written work.

The remaining ten minutes are now spent as follows: Three minutes are used in eliciting a summary from the class. This outline is written upon the board and the pupils simultaneously copy it into their note-books.

A brief discussion gradually leads up to the next day's assignment, which the teacher writes upon the board for the class to copy.

During the remaining time, the teacher explains the highlights of the new work.

When demonstrations are to be made the twenty minute discussion period is curtailed.

In the foregoing manner the ordinary forty minute recitation period is utilized to the utmost in obtaining complete and efficient pupil participation.

## REACHING THE INDIVIDUAL IN MATHEMATICS INSTRUCTION.*

BY J. M. JACOBS,
*Glenville High School, Cleveland, Ohio.*

An article appeared in a recent issue of The Saturday Evening Post written by Christian Gauss, Dean of the College, Princeton University, under the title, "Why Students Fail." Data gathered from deans of colleges in all sections of the country and presented in this article assign many factors as contributing causes of failure in college but the overwhelming cause of failure cited is not lack of intelligence, as one might suppose, but unwillingness to work. As Dean Thomas Arkle Clark, of the University of Illinois, puts it: "An overwhelming number of students fail, I think, however, because they are not willing to work hard."

Cannot we, as high school teachers, testify to the truth of this statement if it is applied to high school pupils? Can we not cite instance after instance of a boy or girl with average ability who by dint of consistent application has made a creditable record in high school and in some cases, even in college?

Granted, then that a large number of the failures in our classes are due, not to inability to do the work, but to a disinclination to do it, what methods shall we employ to secure a maximum amount of effort from our pupils?

Nothing approaching maximum endeavor will be secured unless we learn the individual difficulties of our pupils. A teacher may give what he considers a clear explanation of a certain operation that may prove to be wholly unintelligible to some members of the class. Just because a teacher understands the subject well himself, isn't he apt to underestimate the difficulties of the learner? Isn't he prone to lapse into verbose explanation before the class when his teaching might be much more effective if he would set everyone to work and sit down with this pupil and that one, and help the individual attack his problem?

Of course explanations before the class are necessary, but these are only beginnings. We must assist the individual pupil as he works. The front of the classroom is not

*A paper read at the Mathematics Division, North Eastern Ohio Teachers' Association, Cleveland, Ohio, Oct. 31, 1930.

the only place for a teacher to occupy. He must hold himself responsible, within the limits of his ability and energy, for the accomplishment of each individual in his classes.

What is the chief problem in methematics instruction? To me it is this: First, how can we devise a classroom technique that will secure a maximum amount of endeavor from each individual pupil while he is with us? Secondly, how can we make the assignment so that every pupil can with a reasonable amount of effort accomplish what is expected of him? I shall not attempt to provide complete answers to these two questions. My purpose is to offer a few suggestions.

These suggestions concern individual instruction—not individual progress of pupils. Individual progress of pupils seems to me to be unsatisfactory for two reasons: First, it permits of no class instruction except at the beginning of a course. This allows the teacher to give but a minute and a half or less to each pupil in a class of thirty during a forty-five minute period. So little instruction is entirely inadequate for most pupils. Secondly, if individual progress is permitted, the class ceases to function as a unit. Class discussions and the exhibition of solutions and proofs at the board are not possible. The knowledge that every member of the group is attempting to solve a certain problem or prove a certain theorem is a strong incentive for a pupil to do his best. This incentive is lost where pupils progress at their own rate.

With this limitation upon the meaning of individual instruction, I shall attempt to point out a few ways in which more consistent endeavor and achievement may be secured from individual pupils in some of the high school courses in mathematics. The following suggestions are not guaranteed to produce astounding results. They are merely methods that have been found helpful by certain teachers in the teaching of mathematics.

## Ninth Year Algebra

What a class in 9A Algebra assembles, the pupils put their home work in a wire basket on the teacher's desk. Suppose the home work is on the addition of fractions. The teacher puts ten or twelve problems on addition of fractions on the board. Some of them may be the same problems as

the pupils had for home work, others are different. The words "Class Work" are written at the top of this list. The pupils go to work at it immediately. The teacher then passes from pupil to pupil, watching them work, offering suggestions and giving help to those who need it. The pupils who find the subject difficult are seated in the front of the room. The brighter ones sit in the rear. A pupil is required to work at an exercise until he has it correct. That a pupil may know when his result is correct, he checks it. Some pupils may finish all of the list of exercises, others will not. After sufficient time has been given for the completion of the class work, pupils may change papers and mark them or the papers may be given to four or five of the best pupils in the class for marking.

This type of recitation is occasionally varied by sending as many pupils as possible to the board and giving each a different problem or group of problems to work. Those at their seats work at still a different exercise or group of exercises. When these exercises are finished they are checked quickly by the teacher. No time is taken for explanations by the pupils themselves.

Statement problems may be treated in the same manner. A few of one particular type may be written on the board and the pupils solve as many as they can. A pupil is asked to read such a problem aloud, but he is stopped when he has read the first sentence or any part of it that can be translated into algebraic symbols and he is asked to translate them. Everyone writes as the equation is given. With practice and appropriate explanation by the teacher, it is not long before most of the class can solve that particular type of problem. There are not many types of statement or word problems in first year algebra. If they can understand English, pupils can solve statement problems. The ability is acquired gradually after a large number of such problems are solved.

Class work serves to keep every member of the class busy all of the time.

When the class work is finished, another shorter list of exercises is written on the board. These are taken from the following day's assignment. The pupils start work on these with abundant explanation by the teacher. They fin-

ish as many as they are able before the period ends. On some assignments an able pupil completes the following day's home work before he leaves the class. As the class works, the instructor assists the individuals who need assistance most.

Frequently, it is preferable to have the class work several exercises in the next day's assignment at the beginning of the hour to insure plenty of time for this work. Especially is this true of advance work that is entirely new. Very often, half the period is spent on the assignment.

### Plane Geometry

At the beginning of the course in geometry, pupils in Cleveland high schools are assigned to fast or slow classes according to their P. L. R. and previous achievement indicate their ability to meet the requirements of the subject. Pupils whom we assign to fast moving classes, designated as X groups, are expected to cover practically all of the material in the text. Pupils assigned to slow moving classes, designated as Z groups, are required to prove only certain typical exercises in each list in the text, but they must master these if they are to obtain credit for the course. Their work parallels that of the X groups, the difference being that there is less of it. Certain topics, such as inequalities and loci, are omitted entirely in the case of the Z groups. The material to be covered by the Z groups is furnished in detail to the teachers.

The Z pupils make marks in the 70's and no higher. In the majority of cases these pupils do not receive marks of 80 or above in any of their major subjects. Pupils in Z classes are frequently under the impression that because they have been assigned to a slow class they are limited in the mark they can earn. We tell them that there is no limit placed on the mark they can make, that when they show that they have the capacity to do X work they will be transferred to an X group. Tests for these two groups of course are different, but pupils in the slow classes have the privilege at any time of trying the X tests. Pupils are frequently transferred from one type of class to the other.

As to the recitation in geometry.—Here, too, I think written work should occupy the greater part of the period. We can not dispense with the oral demonstration and discussion

of it, but I should think this ought to require only a small fraction of the period. In an oral demonstration, one person need not give the complete proof. He may be interrupted several times and other members of the class be asked to give the next step or the reason for a statement already given. If the oral demonstration is relied upon entirely, half the class are idle and are accomplishing nothing. It is a wasteful and ineffective procedure.

When a geometry class assembles, they, too, put their home work in a wire basket on the teacher's desk. We believe in home work. Pupils are required to write propositions and exercises. There may be copying, but a pupil may learn a little when he copies from another. At the beginning of the period, time is taken for the assignment. The nature of an assignment of course, varies with the character of the class, but unless the class is exceptionally good, the pupils draw the figure on paper and jot down as much of the proof as the class can work out together in the time allotted. Whenever it is feasible, pupils are asked to write the proof for a theorem without consulting the text. This gives them confidence. Half the period is not too much time to devote to the assignment unless the class consists of exceptionally bright pupils.

After the assignment for the next day is disposed of, some one may be called upon to give the proof for the theorem or exercise assigned the preceding day. When the oral demonstration has been given, the whole class can write it. If it is apparent that most of the class cannot write it without assistance, some one may give the oral demonstration slowly while the rest of the class write it down. Two or three exercises may be included in this class work. For brevity the figure at the board may be used and none drawn on the papers. Discussion may continue as the pupils write. The teacher passes from desk to desk assisting those who need assistance and asking questions, the answers to which should help the weak pupil. As the papers are finished, they may be handed to two or three of the best pupils for marking. There is not always sufficient time for these pupils to mark all of the class work papers. The instructor must frequently complete the marking of papers—many times do all of it. However, it is scarcely necessary to mark the

class work of every day. If this were done, the emphasis would be shifted from teaching to marking papers and under these circumstances the teacher's effectiveness declines.

When an oral demonstration is given, pupils are encouraged to ask questions of the person at the board, for their own benefit, as a criticism, or as an aid to the person reciting when he cannot proceed further. Insofar as possible, the validity of statements used in a proof should be passed upon and settled by the members of the class rather than by the teacher. It promotes interest and enthusiasm to turn a recitation over to pupils entirely for a few minutes some days. Freedom of thought and expression should be cultivated in pupils. Probably we stifle thought and expression more than we know.

With patience, we can see a problem through the pupil's eyes. The teacher's job is not only to make clear the correct procedure but to see the pupil's questions as he sees them and answer them to the satisfaction of the pupil. Whenever time permits, a proof differing from the one given should be heard, and if correct, praised, or if incorrect, diplomatically criticised. Should we not encourage individual thinking in our classes? Is this not one of the main purposes in the teaching of mathematics?

For exceptionally slow pupils in geometry I have found no better method than to send several of them to the board and assign to each a different original exercise, and let them stay there until they finish it. Of course they need assistance but they need not be given too much. When they have proved an exercise with some assistance it may be wise to have them erase it and rewrite it. This process at first is very slow, but the pupils get an understanding of a few tools and methods that they do not get from explanations or study. The same end may be accomplished by letting these pupils write at their seats but it can be accomplished more quickly with them writing at the board, for mistakes can be seen and corrections made much more rapidly. While this very slow group works at the board the rest of the class can be writing assigned exercises at their seats,—the class work referred to above.

Last semester we divided the material of the first half of plane geometry into units and prepared assignment

sheets for each day's lesson. These were handed to the pupils. Another Cleveland high school tried the same experiment. The units are those under which the material usually falls in the text, such as Unit I—Introduction, Unit II—Rectilinear Figures, Unit III—Parallel Lines, Unit IV —Quadrilaterals, etc. At the top of each assignment sheet is written the following items: Purpose of the assignment, references or the actual minimum assignment, maximum assignment which is to be done by the fast groups in addition to the minimum assignment, and directions for working out the assignment. These items occupy but a fifth or a sixth of the sheet. The rest of the sheet is given over to drawings for theorems and exercises, the words Hypothesis, Conclusion, Plan, Proof, Statements and Reasons. Suggestions are given and difficult steps are written out partially or in full on the sheet.

One of these sheets was prepared for every assignment in the first half of plane geometry. It was typewritten on a stencil and copies run off on a mimeograph machine. Over a hundred hours work were required in their preparation. We are now preparing a set of such sheets for the second semester of plane geometry.

At the beginning of each unit's work a sheet is prepared showing what is required of pupils of different abilities in that unit. Three concentric circles are drawn on the sheet after the suggestion of H. L. Miller who for years was principal of the University of Wisconsin High School. In the smallest circle are drawn the figures representing the theorems, corollaries and exercises a pupil must be able to prove in order to secure a mark between 70 and 80. Between the inner circle and the next larger circle are placed the figures for those exercises which a pupil must be able to prove in order to secure a mark between 80 and 90. And between the middle circle and the outer circle are placed the figures for the exercises which a pupil must be able to prove to secure a mark above 90.

At Glenville we give departmental tests once every three weeks. For the review assignment preparatory to these tests practice tests covering the work of the preceding three weeks and similar to the regular tests, have been prepared and these are given to the pupils to be worked out

as their review. These practice tests emphasize the important parts of the three weeks material and give the pupil an idea as to how well he is prepared for the real test. They give the pupil a definite outline of work to accomplish in his review.

After these sheets and practice tests had been tried for a semester, the teachers and pupils were asked to write their opinions regarding them. Out of one hundred eighty-four pupils, one hundred sixty-seven were in favor of them, seventeen were against their use. The teachers are divided in their estimates of them. Some favor them others do not. One mistake we seem to have made is to have allowed the pupils to fill in blank spaces on the sheet instead of writing the assignment entirely on a separate sheet and using the assignment sheet as a guide. Filling in blank spaces and finishing statements started on the sheet did not teach the pupil geometry.

At the opening of school this fall, all of the teachers asked for the sheets again. Some wished to use them through the introduction, then to use them only occasionally, others are using them continuously.

They are very convenient when starting the course, to hand pupils who have been absent, and for weak pupils who need suggestions frequently. They enable a pupil to proceed with his assignment when without them he might frequently be baffled and unable to complete it. The teachers are agreed as to these points and to the value of the practice tests. The other Cleveland high school using this device, gives a favorable report of it.

Dr. Judd of the University of Chicago says it is incumbent upon the teachers of mathematics to make their subject less difficult for the learner. We are trying in a measure to heed his advice in the preparation of these assignment sheets.

Geometry, as well as other courses in mathematics, is an activity subject and pupils learn its methods and processes by actually using them. Isn't it a question whether they learn the subject in any other way? When a pupil has his geometry before him and tells me he is studying geometry, he is told that he is wasting his time, that the only way he will accomplish anything is to write out his assignment.

We favor drill sheets,—tests on one type of exercises or method of proof. There are sets on the market. They can also be prepared, stenciled and mimeographed for class use. These short tests may consist of twelve or fifteen exercises on such topics as the following: Determining the equations necessary to prove triangles congruent by one particular method—one or more figures to be used; proving triangles congruent by five or six different methods—a.s.a.=a.s.a., h.a.=h.a., etc., to be the only answers; determining hypotheses and conclusions—one or more figures to be used; proving lines parallel, lines cut by a transversal; proving quadrilaterals parallelograms; the sum of the interior angles of a polygon; the measurement of angles in a circle, etc.

Pupils need this kind of practice, they like it, but there is not an adequate number of such exercises in the text. There isn't space for them.

Despite these devices for making the work in geometry less difficult, some pupils still require a special attention. As an additional aid to the weak pupil, we provide a coaching class for those who are failing in geometry or other mathematics courses. The teacher in charge of this class assists the pupils in the preparation of their assignments. Only failing pupils are assigned to the coaching class. When a pupil has improved his work to the satisfaction of the teacher who assigned him, he is not required to report any longer. He attends this class in addition to his regular class in mathematics. We are able to save half or more of those assigned.

Many of our teachers are willing to stay with pupils after school hours and help them with their work. Undoubtedly, pupils may impose upon a teacher in this respect, but in many cases there is need of such help and it is the only way in which some pupils will be enabled to pass the course. Teachers are provided with the P. L. R.'s of most of their pupils, so they have a fairly accurate index of the abilities and needs of the individuals in their classes.

### INTERMEDIATE ALGEBRA

We require pupils in this subject to write out their assignments every day. They work only the even numbered or odd numbered exercises in most lists, but they are asked

to complete the entire lists of statement problems. Half or more of the period is devoted to written class work and the remainder of the period to written work on the advance assignment. When the seven or eight class work exercises have been finished they are turned over to two or three of the most capable pupils in the class for checking. The rest of the group proceed with the next day's assignment. If class work is not finished, pupils take it with them, complete it and turn it in the day following.

We don't accomplish much with board work. When I ask a pupil to put a problem on the board it is one that he has not been able to solve. I see no purpose in having problems copied on the board that have been already worked. If a pupil will attempt an exercise at the board and stay with it until he finishes it, with assistance if necessary, then he has made a step forward. Pupils should not, in my opinion, be sent to the board and all of them be required to solve the same exercise. There is too much copying, the work becomes mechanical and meaningless.

Home work is given no mark—it is merely checked so that we may know whether a pupil is making a reasonable amount of effort. The marks made in class work and on the three tests determine the final marks.

At test time, two tests are given—one we term a regular test, the other,—a minimum requirement test. Any pupil taking the latter and passing it must be satisfied with a mark in the 70's. If a pupil fails to make a satisfactory mark on a test, we are willing, if the case is a deserving one, to give a similar test again providing the pupil has corrected his first one and has shown some evidence of having reviewed the material covered.

Home work, class work, practice tests, regular tests and when necessary, retesting. This is our method.

To prepare pupils for College Entrance Board and scholarship examinations in plane geometry, we have them write out the answers and proofs to several lists of review exercises covering the subject. After these are completed, the proofs for the starred theorems and for the more difficult original exercises of the text are written. Proofs are condensed as much as possible. Last year our candidate for a Harvard Scholarship wrote out the complete proofs for all

the starred theorems of plane geometry in ink in his note book. Incidentally he won the scholarship. After proving the starred theorems and difficult originals of the text, we have the pupils take several College Entrance Board examinations of recent years.

The lists of review exercises found in many algebra texts furnish useful material for preparing pupils for college entrance examinations. A boy who was especially weak in algebra recently completed a list of two hundred and fifty review exercises as part of his preparation for such an examination. Our teaching in this field is entirely with the individual.

Last year, we initiated a mathematics club at Glenville. The club contributes a mathematical puzzle to each issue of the school paper. With it are printed the names of the pupils who answered correctly the puzzle of the preceding issue. A mathematics club furnishes the means of acquainting a certain group of capable pupils with some practical and some extraordinary phases of the subject. Our club this year has planned to study the relationship of mathematics to high school physics, chemistry and art.

A strong influence on the individual performance of each pupil in a class is the atmosphere of the class room. If the members of a class know they have a definite task to perform during the recitation period and are not hampered unduly by restrictions on their behavior, they set to work naturally, confer with one another occasionally, ask questions of the teacher and even go to the board and try a problem which they have been unable to solve. A pupil has the right to have a problem explained which he has tried conscientiously but unsuccessfully. The class room is a workshop—not a place for the exhibition of the achievements of the brightest members of the group. A teacher can cultivate in a class a spirit of industry and of rivalry that will spur every member of the group to give his best.

We may prepare an elaborate system for reducing failures in mathematics and administer it efficiently, yet still fail in our task. Only when we have added to such an artificial system sympathy with the pupil's difficulties and an eagerness to help him understand and appreciate the subject, will we have reached the individual in our classes in mathematics.

**Annual Meeting**

## EASTERN ASSOCIATION OF PHYSICS TEACHERS

**One hundred seventeenth meeting**

## MECHANIC ARTS HIGH SCHOOL

**Boston, Mass.**

## SATURDAY, MARCH 7, 1931

PROGRAM

9:30 Meeting of the Executive Committee.

10:00 Business meeting.
- Annual Report of the Secretary.
- Annual Report of the Treasurer.
- Report of the Nominating Committee.
- Election of Officers.
- Election of New Members.
- Reports of Committees.

10:30 Annual Address of the Vice-President, Mr. Louis A. Wendelstein, High School, Everett, Mass.

11:00 Address: "The Teaching of Physics in English Schools." Mr. Spencer R. Humby of Winchester College, and old English "Public School" of a type similar to Exeter Academy, where Mr. Humby is located for six months.

12:00 Report of Apparatus Committee. Mr. John C. Packard, Brookline High School, Chairman, in charge. The Apparatus Committee was given an hour for the display and description of ingenious devices made, designed or readapted by the teachers themselves for effective use in their own schools.

1:00 Lunch.

2:00 Inspection of New Laboratories at the Mechanic Arts High School.

2:30 "Class Room Demonstrations in Electricity." James P. Farnsworth, Mechanic Arts High School, Boston.

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## OFFICERS FOR 1930-1931.

President, Burton L. Cushing, Mechanic Arts High School, Boston, Mass.

Vice-President, Louis A. Wendelstein, High School, Everett, Mass.

Secretary, William W. Obear, High School, Somerville, Mass.

Treasurer, William F. Rice, Jamaica Plain High School, Boston, Mass.

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## SECRETARY'S REPORT.

Our three meetings of the year have been held May 10, 1930 at the Lowell Textile Institute, Dec. 13, 1930, at the Massachusetts Institute of Technology and March 7, 1931, at the Mechanic Arts High School, Boston. On Oct. 28, 1930, a trip was made to the Metropolitan Theater, Boston for the purpose of inspecting the organ. The speakers and subjects have been of the usual high standard and the interest at the meetings has been well maintained.

There are now 111 active members and 64 associate members making a total of 175, besides 2 honorary members. This is a considerable increase over the total of 158 a year ago. The increase has been entirely in the active membership and this is undoubtedly due to the fact that for the extra dollar a full years subscription

to SCHOOL SCIENCE AND MATHEMATICS is obtained. As a matter of historical interest I record here the admission May 10, 1930 of the first woman to active membership.

Our membership, finances, and attendance at the meetings show a healthy condition of the Association but there are still many more Physics teachers who ought to avail themselves of the opportunities afforded by membership in the Eastern Association of Physics Teachers.

Respectfully submitted,

W. W. OBEAR.

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## REPORT OF THE TREASURER, 1930-1931.

| | | |
|---|---|---|
| Bal. from 1929-30 | | $349.98 |
| Receipts: | | |
| Dues Act. 1930-31 | $317.00 | |
| Act. 1929-30 | 13.25 | |
| Ass. 1930-31 | 104.00 | |
| Ass. 1929-30 | 2.00 | |
| Interest | 11.36 | |
| | $447.61 | |
| Extra for magazine | 12.00 | $459.61 |
| | | $809.59 |
| Expenditures: | | |
| Printing and Stationery | $ 78.82 | |
| Expenses of Meetings | 36.00 | |
| Postage | 19.71 | |
| Clerical Work | 20.75 | |
| Salary, Secretary, 2 years | 100.00 | |
| | $255.28 | |
| Paid SCHOOL SCIENCE AND MATHEMATICS | 282.70 | $537.98 |
| Balance | | $271.61 |
| Balance March, 1930 | | $349.98 |
| Balance March, 1931 | | 271.61 |
| Deficit for year | | $ 78.37 |
| Deficit previous year | | 129.09 |
| Assets: | | |
| Jamaica Plain Trust Co. | | |
| Checking Account | | $ 26.21 |
| Savings Account, No. 16067 | | 245.40 |
| | | $271.61 |

March 7, 1931

Respectfully submitted,

WM. F. RICE, Treasurer.

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The nominating committee, Mr. James W. Dyson, Mr. Wallace E. Richmond and Mr. Ralph C. Bean presented the following condidates and they were elected to serve for the ensuing year:

President, Frederick M. Boyce, Phillips Academy, Andover.

Vice President, Lawrence A. Howard, East Boston High School.

Secretary, William W. Obear, Somerville High School.
Treasurer, William F. Rice, Jamaica Plain High School.

**Executive Committee.**

Arthur V. Donnellan, Jamaica Plain High School.
Ralph B. Delano, Memorial High School, Boston.
Robert W. Perry, Malden High School.

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The following members were elected:

Active—Clair F. Benson, High School, Biddeford, Me., Saco, Me.; H. Marjorie Eastman, Dana Hall, Wellesley, Mass., Dexter, Me.; Clyde E. Nason, High School, South Portland, Me., 265 Ocean St., South Portland, Me.; Allan B. Smith, Moses Brown School, Providence, R. I.; Edward Sawin, High School, Cranston, R. I., 36 Rolfe St., Cranston, R. I.

Associate—Carl Johnson, North High School, Worcester, Mass., 73 Davidson Road, Worcester, Mass.

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## REPORT OF COMMITTEE ON MAGAZINE LITERATURE AND NEW BOOKS.

ROBERT W. PERRY, *Chairman, High School, Malden, Mass.*

### MAGAZINE LITERATURE.

Journal of Chemical Education, December, 1930, "What is Light," by Arthur H. Compton. February, 1931, "Glass versus Slate Blackboards," by Foster Dee Snell and Beatrice S. Fox.

Scientific American, January, 1931, "Practical X-ray Crystal Analysis in Engineering," by V. E. Pullin. February, 1931, "Engineering Aspects of Michelson's Velocity of Light Experiment," by Edgar Nichols. Concerning the job of building a mile long airless pipe.

Power, February 24, 1931, "Gamma Rays in the Power Field," by Robert F. Mehl and Charles S. Barrett. Concerning use of gamma rays to penetrate heavy steel machine parts (6 to 10 inches thick) and register flaws on photographic plates.

The Living Age, February, 1931, "Interviewing Eddington," by J. W. N. Sullivan.

Education, February, 1931, "The Foundation of Science Teaching," by John J. Birch.

Time, March 2, 1931, "Science," Francis F. Lucas, of Bell Telephone Laboratories has a new microscope for use in studying structure of metals. It uses visible light and magnifies 12,000 times.

Popular Science, March, 1931, "Mercury Turbine Now a Success," by Earl Chapin May. Concerning a successful plant operating at Hartford.

### NEW BOOKS.

"Everyday Physics," by Carleton John Lynde, Professor of Physics, Columbia University. Published by the Macmillan Co.

This is a book which introduces a great many physical principles from a practical point of view. Furthermore, the practical illustrations which the author uses are well within the experience of high school pupils. Many of them are taken from household appliances.

The book has been written for a first course in Physics and might well be used in the tenth grade.

The English system of measurement is used almost entirely and this seems a good idea in an elementary Physics course. It furnishes one more bond between the principles of Physics and the experiences of everyday life.

The fact that the author has included an introduction to the idea of the correlation of matter and energy is an indication that the book is right up to date.

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## REPORT OF COMMITTEE ON CURRENT EVENTS IN PHYSICS.

CLARENCE M. HALL, *Chairman, Central High School, Springfield, Mass.*

### "HOT" ICE.

Dr. Bridgman, of Harvard University, has frozen water at a temperature of 180 degrees F, only 42 degrees below its boiling point. It is real ice, but it is hot, so hot that it will burn one's hands.

It was made by putting water under a pressure of 290,000 pounds, or 145 tons, per square inch. Dr. Bridgman found that ordinary ice becomes unstable at pressure greater than 29,000 pounds per square inch and is replaced by other forms, one of which is stable at 290,000 pounds and at a temperature as high as 180 degrees F.

### ELECTRICAL EYE SEPARATES METALS.

Prof. Drier, of the Michigan College of Mining and Technology, invented the apparatus. The apparatus provides for particles of the metal materials under test to fall upon a moving, black, endless belt. They pass under a constant source of light, a part of which is reflected back to a photo-electric cell. Some metal particles reflect more light than others and thus set up different currents through the cell, which are amplified to operate a mechanical apparatus that removes the material whose reflection index is above or below a certain value.

### A HUNDRED USES FOR TREE BARK.

This tree is known as the cork oak.

For at least 2300 years cork has been used by man.

It is highly compressible as a pressure of 14,000 pounds per cubic inch foretells.

Now it has become, suddenly, an object of keen industrial interest. Cork board in huge quantities is needed for large plants that are being built for: quick freezing of meats and vegetables to be retailed in package form and kept at sub-zero temperatures in refrig--erator cars, trucks, and storage cases.

Since dead air, in finely divided spaces such as cork cells, is, next to a vacuum, the best insulator known, cork will keep heat in or "keep cold out."

For the same reason cork is a poor conductor of sound and vibration, and is therefore widely used in acoustics.

Cork has uncommon resistance to deterioration due to its chemical inertness.

When cork bark is cut cleanly the exposed cells each act as a tiny vacuum cup. This gives cork a gripping and polishing property now widely utilized. Plate glass, mirrors and windows, fine glass and crystal, and optical lenses are polished on cork wheels.

Angle for repose for leather on an inclined plane is 18 degrees, for rubber it is 28 degrees, and for cork 42 degrees.

Portugal and Spain lead the world in production of cork. Algeria, France, Tunisia, Italy and Morocco come next in order.

### COPPER OXIDE "SANDWICH" CONVERTS LIGHT TO ELECTRICITY.

This is done by a new type of cell that converts light directly into

useful quantities of current. Dr. B. Lange of the Kaiser Wilhelm Institute for Silicate Investigation is the inventor.

The essential part of the new cell is a "sandwich" of copper oxide between two layers of metallic copper.

In Dr. Lange's cell, the light falls on one of the thin copper layers and electrons are driven off. The electrons pass through the exceedingly thin layer of copper oxide and when they reach the other copper plate an electric current results. The cell operates without the slightest appreciable lag, because of the short distance the electrons travel.

The current given off is powerful enough that when a rapidly flickering light shines on the cell, the current can be fed into a loud speaker and a note vibrating at the same rate as the light can be heard.

Its advantages are that it does not show fatigue as does the ordinary photo-electric cell. It can be operated indefinitely without loss of efficiency. It is much more sensitive to the infra-red rays, too long to be seen. Dr. Lange suggests that it will be useful as a photometer to measure light intensity. The current given off is directly proportional to the light falling on it, over a long range of brightness.

### X-Ray "Eyes" See Motion in Solids.

A device with 50 X-ray-seeing eyes has been perfected at the California Institute of Technology.

These eyes have "seen" and recorded on photographic negative evidence that the minute particles of solid substances—such as a piece of graphite, aluminum or beryllium—are in tremendously rapid motion.

The pictures add support to recent astonishing discoveries by physicists that possibly all the solid matter in creation is, in some not yet understood fashion, only a form of wave motion.

So nearly are these wave motions of the particles of graphite, aluminum and beryllium like the wave motion of light that some scientists recently have called matter "bottled radiation."—Courtesy of Springfield Union.

### Echo Altimeter for Airplanes.

Echoes are now harnessed to enable aviators to land in dense fog.

A new altimeter, developed by army air corps and General Electric engineers, automatically measures the altitude of a plane by the time taken for a whistle blast to make a round trip between the ship and ground.

The new device, called a sonic altimeter, is patterned after the sonic depth finders which have found wide use in water craft for soundings and have enabled scientists to chart hitherto unknown depths of the seas.

Aircraft equipment includes a pressure tank, a whistle, a transmitting and a receiving megaphone joined by a tube, a dial measuring the altitude in feet, and a stethoscope fitting into the pilot's ears.

A blast from the whistle is magnified by one megaphone pointed to the ground and the reflected sound caught on the rebound by the receiving funnel.

The dial automatically registers the altitude according to elapsed interval but below 50 feet the tube between blast and echo is so short that a stethoscope is employed.

### 13 Above "Absolute Zero" Recorded by New Device.

A device which records temperatures as low as 260 degrees below zero Centigrade, only 13 degrees about "absolute zero" has been developed at the bureau of standards.

The apparatus calibrates thermometers with great accuracy at extremely low temperatures.

The low temperature is obtained by boiling liquid hydrogen at reduced pressure in a special bottle surrounded by a container filled with liquid air.

### Television Arc.

J. L. Baird, British television pioneer, has recently demonstrated how the arc cannot only be made to sing, or talk, in response to a properly modulated current, thus acting in the same way as a loud speaker, but how it can be made to respond to the rapid variations of a television circuit. If it proves as successful as is promised by a preliminary demonstration, this inventor has achieved something that has been sought by many, namely, a light source that varies instantly with the current supplied to it, and that is also of great brilliancy.

### Premature Blast Wrecks Rocket.

*Explosion of Experimental Device in Austria Injures Three.*

A rocket experiment which its author hoped might lead eventually to a trip to the moon has ended with the premature explosion of the rocket on top of Mt. Redorta, near Vienna, with injuries to three persons.

The rocket was the work of Dr. Darwin Lyon, New York scientist, who had designed it to carry instruments into the stratosphere to determine the density, composition and temperature of that medium at an altitude of about 93 miles. The rocket was of aluminum, about 15 feet high and weighed about 300 pounds.

### Mirages.

Mirages still are seen on the deserts of California and Nevada when the air next to the ground becomes hot and acts as a mirror for light rays. In former decades the surface of the prairies in Kansas and Texas was unbroken by the plow. Every few years it was burned over by the prairie fires so that grass and bushes were destroyed. The hard, smooth surface of the ground was heated by the sun and heated the air next to it. This caused the mirages, which now are ended forever by the plowing of the land.

### Human Eye Versus Photoelectric Cell.

The human eye can see stars about five or six times as faint as the faintest that can be detected with the photoelectric cell, declared Dr. Joel Stebbins, professor of astronomy at the University of Wisconsin, in Cleveland, speaking before the astronomical section of the American Association for the Advancement of Science.

The photoelectric cell yields an electric current when light falls on it. Dr. Stebbins and others have used it to measure the brightness of stars, by measuring the current when the starlight, concentrated by a telescope, shines on the cell.

To test the sensitivity of the cell, Dr. Stebbins took it off his telescope and pointed it at a standard candle actually placed a mile away across the lake at Madison. The cell was able easily to detect the light, and Dr. Stebbins estimated that the candle could have been detected if as far as three miles away. The eye can see a candle at

six or seven miles, and Dr. Stebbins thinks that the cell could detect it at this distance if the light were white in color, like some of the stars, instead of yellowish. Therefore, the unaided eye is just about as sensitive as the photocell.

But the pupil of the eye is about a quarter of an inch in diameter, and when the light is concentrated by a 10-inch telescope lens the light-gathering power of the eye is increased 1,600 times. The opening of the photocell, however, is about an inch in diameter, so that the same telescope only increases its power about a hundred times. Therefore, in practise, the eye can see fainter stars than can the photocell through the same instrument.

### Largest X-Ray Tube.

To fight cancer a 900,000-volt X-ray tube, far the biggest in the country, is being built for the New York Memorial hospital.

Ordinary X-rays, outdone by radium in a series of tests at Memorial hospital, are coming back to renew their bid for supremacy.

The present greatest X-ray tube is a 600,000-volt apparatus higher than a bungalow at California Institute of Technology.

A 5,000,000-volt tube has been operated at the Carnegie institution of Washington, but its great power is only a momentary spark, instead of the continuous stream sought in medicine and industry.

### *Details Not Yet Divulged.*

The new 900,000-volt tube is under construction by the General Electric company. Its details have not been made public, but it is expected to take the form of three tubes, each of 300,000 volts hooked up end to end in a "cascade."

### Practical Sun Motor?

Dr. Bruno Lange, the young German physicist who recently invented a new kind of photoelectric cell composed of a layer of single molecules of copper oxide spread over the surface of a plate of metallic copper, has applied his invention to the construction of a sun engine said to be powerful enough to operate a small electric motor.

### Electricity From Germs.

Growing masses of deadly disease germs generate electricity just as real and effective as the output of the familiar dry cell that rings your doorbell, Dr. Barnett Cohen of Johns Hopkins Medical School reported to the Society of American Bacteriologists.

Out of bacteria, some of the sort that cause diphtheria, dysentery and other ills, he has constructed what he calls a "bacterial battery" which furnished current of about two milliamperes at a pressure of 35 volts. This was built up of unit cells composed of a few teaspoons of growing germ culture coupled to a sterile solution and from each small cell there discharged through 300 ohms resistance about a hundredth of a milliampere of electricity each minute.

### Focussing Microphones.

The new microphone is based in principle on antiaircraft signal devices used during the war. It is believed to be the closest mechanical approach to the human ear ever developed for radio.

It functions much like a photographic camera, in that it may be focused on a certain area and only sounds created in that area will be picked up by the microphone. The Focus may be set to cover a large area or concentrated on one particular spot, while sounds "not

in focus" will not be heard by the listening audience.

### The Red Shift in Nebular Spectra.

A discovery seven years ago by Maj. Edwin P. Hubble, who determined that nebulae were island universes separate from our own galaxy or milky way, created a new problem for Einstein. This problem revolves around what astronomers call the red shift of distant nebulae. In spectroscopic photographs the spectrum lines of distant nebulae shift toward the red.

Hubble interprets this red shift as apparently showing the rapid recession of distant nebulae from our nebulae. That is, the nebulae at 100,000,000 light years distant, or 600,000,000,000,000,000,000 miles, are speeding away from the neighborhood of the earth at a rate of 7200 miles a second, or about 26,000,000 miles an hour.

Astronomers generally interpret this red shift as an apparent velocity. This is known as the Doppler effect. Einstein suggested that some other conclusion for this effect might be looked for, but said he did not know how to account for it.

One suggestion previously has been made that this red shift might be interpreted by loss of energy as they go through long distances. Experimental laboratory tests have produced no positive evidence.

### New Steps Taken to Enable Vision Over Telephones.

*Circuit in New York City Able to Reveal Faces of Persons Talking to Each Other.*

Several recent steps to enable seeing over the telephone are related by Dr. Herbert E. Ives in the Bll laboratoris.

For 10 months the laboratories have maintained a telephone circuit several miles long between Broadway and West Street in which faces of persons talking to each other are visible, recognizable and in natural colors.

A deep-red light now has been incorporated in the scanning beam, which originally was wholly blue. The result is to scan by purple instead of blue. As the human eye is very insensitive to blue, Dr. Ives says, use of blue alone made the yellows and reds in the face too dark in comparison with such whites as a linen collar.

Two new type photo-electric cells have been added, making it possible to illuminate the telephone booths with yellow light. This keeps the facial image from being scanned against too black a background. It does not interfere with television because the apparatus is unresponsive to yellow.

### Navy War Plane.

*Ship Leaves Ground in 400 Feet, Makes 350 Miles an Hour; May Be Schneider Entry.*

A naval fighting plane which observers claim attains a speed of 300 miles an hour and an altitude of 29,000 feet was secreted under armed guard today, Feb. 13.

Completed yesterday by the Curtiss-Wright Corporation, the craft was tested by William Crosswell, company pilot, at Mitchell Field. Crosswell took it off the ground in less than 400 feet, drove it at 350 miles an hour and pointed it toward the sun until it was two miles in the air.

### The Theremin.

The theremin is the first new musical instrument to be added to a symphony orchestra in 115 years. Although its tone is similar

to that of stringed instruments, the quality is individual, and it is not used as a substitute but as an addition.

A brief explanation as to the working of the theremin was given by the professor. By turning on a switch, negative currents of electricity are projected through a long narrow rod of metal placed at the right of the boxlike instrument. A tone is produced by placing the right hand near the rod, the pitch being determined by the proximity of the hand. The farther away the hand, the deeper becomes the tone, and as the hand approaches the rod, the pitch becomes higher. The volume is regulated by means of a semicircular rod fastened on the left of the instrument. By touching this device, the tone vanishes and by gradually lifting the hand from it the tone increases.

The hand capacity effect near the rod affects the wave length produced by a set of some dozen radio tubes, which output is finally led into a loud speaker. Only slow music can be played satisfactorily.

### Steam Whistle Wastes Energy, U. S. Discovers.

*Experiments Being Conducted to Find Most Efficient Instrument for Fog Warnings.*

Mark Twain was not so far off when he told of the river steamboat which had to stop to get up enough steam to blow the whistle. According to a report of Louis Thompson of the United States Naval Proving Grounds, Dahlgren, Va., a large steam whistle consumes an unreasonably large amount of power. A 12-inch whistle may consume as much as 400 horsepower. The report was given in a discussion of signal efficiency at the meeting of the Acoustical Society of America here.

In precise scientific tests steam whistles made a pitiful efficiency score. Using several hundred horsepower, the 10 and 12-inch whistles wasted over 90 per cent of the energy supplied. The balance was, of course, transformed into actual sound energy.

### Faster Movies.

*New Motion Picture Film Three Times as Speedy as Old.*

From the astronomical observatory to the movie lot a new triple-fast photographic emulsion has come to make motion picture production cheaper and more flexible.

The motion picture film introduced to the profession is described by the Eastman Kodak Company as "the greatest advance in motion picture materials since the introduction of panchromatic film 18 years ago." Its sensitive emulsion is very closely related to one prepared for astronomical photography which has been used to reduce the time required for making exposures through large telescopes. An improvement in the photographic plates used is just as effective in this case as though the telescope itself were increased in size. The super-speed panchromatic plates produced for newspaper photographers are also very similar to the new movie emulsion.

When the movies went talkie it was necessary to banish the familiar arc lamps on account of their noise. Large incandescent lamps are used. These are rich in red light which does not register effectively on ordinary movie negative. The new supersensitive film is affected by both red and green light to a much greater extent than previous film.

Camera men will now be able to "spot-down" their lenses and get increased depth of focus which will allow the actors to move around

with less fear of getting out of focus. Or they will be able to use less light and save money.

ENERGY IN SINGING.

When a prima donna sings with such volume as to fill a large auditorium she is only using about one four hundred thousandth as much power as that required to light one of the 40-watt electric lamps in the rooms. About a tenth as much, or a hundred thousandth of a watt, is used ordinarily in conversation. These figures were cited in Los Angeles by Dr. Harvey Fletcher of the Bell Telephone Laboratories in an address before the Acoustical Society of America, of which he is president. The power used in expressing individual words varies greatly from the average, however. The sound of the long "o" requires several hundred times the power required for "th."

MEN CAN LIVE 350 FEET IN SEA WITH NEW "LUNG."

*Navy Finds Sailors Can Go 50 Feet Deeper Than Subs Expected to Dive.*

The navy has found its men can live 50 feet deeper in the ocean than its most sturdy submarines are expected to descend.

This factor, Rear-Admiral George Rock told the House naval committee today, will decrease the dangers of submarine disasters in less than 300 feet of water.

The most modern submarines in the navy are built to withstand a pressure of 132 pounds a square inch at 300 feet. But men wearing the new "lung" have worked under a pressure of 154 pounds, equal to a depth of 350 feet, without any protection other than the oxygen providing bag.

TWO ELEVATORS IN THE SAME SHAFT.

One elevator shaft is now made to do double duty by causing it to accommodate two elevators—an express and a local.

They do not interfere, and automatic safety devices prevent collision.

The space saved in this way enables an increase in rentals, which represents capital investments of half a million to a million dollars.

Courtesy of Science Service in Scientific American:

The theory that the sun is lighted like a giant electric bulb by electricity under pressure of 10,000,000 volts flowing from inside the sun and heating its atmosphere to incandescence, was advanced by Dr. Ross Gunn, United States Naval Research Laboratory.

A moulded compound, including silicon carbide or Carborundum, which has the quality of preventing the flow of electricity at low voltages while allowing it to pass at high potentials, was developed at the laboratories of the General Electric Company.

Dr. Ernest O. Lawrence of the University of California, with his associate, Dr. N. E. Edlefsen, devised a method for increasing the speed and energy of the protons or hearts of hydrogen atoms so that it may be possible when the method is further perfected to use them as atomic projectiles for smashing the hearts of other atoms, transmuting them into other substances or releasing enormous quantities of atomic energy.

The final value for the most accurate measurement ever made of the constant of gravitation was announced after seven years' work by Dr. Paul Heyl, physicist of the United States Bureau of Standards, to be the fraction 6,670 over 100,000,000.

An electric photo flash-lamp, a German invention, for taking flash-light photographs without noise or smoke was introduced in the United States, the light being made by aluminum foil ignited electrically in a bulb full of oxygen.

LARGEST ROCKFILL DAM IN THE WORLD.

A dam as large as the pyramid of Cheops, wonder of the world for thousands of years, is the modern miracle of industry which features California's latest great hydro-electric project.

Literally moving mountains for its purposes, the Pacific Gas and Electric Company is constructing at Salt Springs high on the Mokelumne River in the Sierra Nevada, the largest rockfill dam in the world. Nearly 3,000,000 cubic yards of granite are being massed across the canyon of the Mokelumne River, in a mighty structure which rises 330 feet from the river bed, extends 1300 feet at its crest from one canyon wall to the other, and measures 900 feet through at the base.

The Pharaohs spent a lifetime in constructing their pyramids. The California power company is spending two years in constructing its dam. 228,000 horsepower will be produced and $40,000,000 will be expended.—Courtesy of Scientific American.

SOME DATA ON PARACHUTES.

If a man is thrown overboard from an airplane, how fast will he fall? The man in the street answering such a question would probably set down an impossibly high figure. As a matter of fact, the Army Air Corps, among other organizations, has tested the speed of a falling dummy, simulating a man, and has discovered that such a dummy, weighing about 180 pounds and the size of a man, with a dummy parachute packed on his back, will attain a speed of only 119 miles per hour after falling some 1200 feet in 11 seconds.

## REPORT OF COMMITTEE ON COLLEGE ENTRANCE REQUIREMENTS.

FREDERICK E. SEARS, *Chairman, St. Paul's School, Concord, N. H.*

The College Entrance Examination Board syllabus and the examinations set by the Board, from year to year, indicate the requirement in college entrance physics for schools represented by this association.

The syllabus was revised some years ago and the form of the paper was altered at the same time. The changes in the syllabus were largely brought about by the omission of certain topics. It was felt by many before the change was made that more topics were included than could be thoroughly covered in a year's work. Other topics were omitted because they seemed unworthy or unnecessary.

The character of the paper was changed at that time to its present form in which seven required questions are included in Part I and a choice is given in Part II of three questions from a possible eight. It will be remembered that the form of the paper as issued for so many included one group for each of the five large divisions into which the subject is so often divided, with opportunity to omit one question from each group.

The revised syllabus is more satisfactory than the one that preceded it but the papers set by the Board since the change was made have proved less satisfactory.

The paper of June 1930 is of course the latest one and the committee has a short report to make on that paper.

In general the committee thinks that the 1930 paper was not too difficult although one member thinks more time should have been allowed to answer as many as ten questions. From outside sources the paper in some cases was thought to be too easy, and one member of the committee agrees with this view. The percentage of those passing was 65.5%, which would indicate that the paper was too easy.

All members of the committee agree in thinking that there was not enough opportunity to choose in answering questions; that a considerable choice should be allowed in all groups or parts on the paper.

As regards the particular questions there seems to be no agreement among the members of the committee. One member thinks that questions 1, 4, 5, 7, 8, 10, 11, 12, 13, 14, are particularly good in that they are concerned with matters of practical interest or that they give a chance to test the pupil's skill in stating clearly what he knows. Question 4 has been criticised as asking for information that most pupils have before studying the subject. Question 10 is too easy, particularly for Part II. Question 14 is good and 15 is also good if some little knowledge of the historical side of Physics may be expected.

The one point of strong agreement among the members of the committee is in the feeling that there should be a wider choice. Seven-tenths of the paper has no choice. Would it not be better to give some choice in Part I and a less wide choice in Part II? It would be even better it seems to me to return to the older grouping with a greater choice than formerly on the more difficult parts, such as Mechanics and Electricity, and possibly Heat also.

The question was raised in the committee as to the advantages of having part of the paper an objective test. One member expressed himself as opposed to the idea and the other two were only mildly in favor of such a possibility.

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Mr. Adelbert H. Morrison, Headmaster of the Mechanic Arts High School was next introduced by Pres. Cushing. Mr. Morrison very heartily welcomed the Association to the Mechanic Arts High School for this meeting. He also spoke briefly of the considerable amount of Science required of the boys in his school.

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## REPORT OF THE APPARATUS COMMITTEE.

The Chairman of this committee, Mr. John C. Packard of the Brookline High School, was unable to be present at this meeting and the program which he prepared was introduced by Mr. William F. Rice of the Jamaica Plain High School. It consisted of demonstrations by various members of the Association. They were of the greatest value to those who saw and heard them and the following outlines are given for the benefit of those who did not attend the meeting.

By WM. F. RICE, *Jamaica Plain High School, Boston.*

For individual laboratory work on the Electro-magnet, have pupils wind a solenoid on a piece of glass tubing of proper bore so that the core may be slipped within it without disturbing the coils.

To show that change of the force acting on a pendulum accelerates it, use a steel ball as a pendulum, and while it is swinging quick-

ly place a magnet under it, near but not touching it. The change in period is easily noticeable. An electro-magnet could be used if the greater complexity is not objectionable.

A Permalloy bar developed in the Bell Laboratories was shown. This is an alloy of iron and nickel and remarkable for its low retentivity.

This was demonstrated by holding the bar in the earth's line of force with the upper end near the N pole of a compass showing an induced S polarity. The rod was then swung 180° so that the upper became the lower end and showed N polarity.

By CLARENCE M. HALL, *Central High School, Springfield, Mass.*

A genuine human ear bone, the anvil, was passed around the meeting as was also a sample of a modern talking picture screen. The screen was of a rubbery composition so as not to have a natural period of vibration and was perforated with small holes, invisible from the audience, to allow the sound to come through without muffling.

A piece of real amber, the "elektron" of the Greeks, was shown. The piece shown contained a small fossil insect. When rubbed on the coat sleeve, the amber attracted a pith ball readily.

A pivoted wooden cylinder containing a cross member which could be set off center was exhibited to show the idea of balancing a rotating crankshaft.

Sympathetic pendulums of wooden balls three inches diameter were operated to help in putting over the idea of sympathetic tuning forks.

Test data were shown to prove that a single master boiler of rather good size will supply steam of dry quality for the latent heat experiment, thus getting rid of the individual small boilers. To save time in the laboratory, the calorimeter cans should have their weights stamped on them, and further time could be saved by using a graduate for the water mass, instead of weighing the can of water.

In specific heat, one master heater is used, the metal cylinders being hung in it for five minutes while the tank is constantly heated with top open to the air.

By A. F. CAMPBELL, *South Boston High School.*

A D. C. Meter board: The circuit contains a triple range voltmeter, a triple range ammeter, two 3-circuit switches, a fuse block, an ammeter cut-out switch, and two binding posts. The 3-circuit switches make it easy to change from one range to another.

By HOLLIS D. HATCH, *English High School, Boston.*

Two pieces of apparatus were shown:

I. To illustrate cooling by evaporation.

A wide mouth bottle was partly filled with ether. A test tube containing a small amount of water was set into the ether, its top extending above the level of the ether. The bottle was fitted with a two-hole rubber stopper. Thru one hole a glass tube extended nearly to the bottom of the bottle. Another tube extending just thru the stopper was connected to an aspirator. By this use of the aspirator air bubbles thru the ether evaporating it so rapidly that

the water is frozen within about five minutes.

II. To illustrate a carbon microphone.

Four discs of arc light carbon were held between a fixed post and a thumb screw and were connected in series with a dry cell and a zero-to-one ammeter. The current varied as the pressure was varied by use of the thumb screw. This meant that the resistance was varied as it does in the carbon microphone of the telephone when sound waves act upon it.

By FRED R. MILLER, *English High School, Boston, Mass.*

Mr. Miller showed a resonance tube that does away with the pouring of water in the wave length of sound experiment. This apparatus was devised by Mr. Boyes of Andover. It consists of a tube about four ft. long and 1¼" in diameter mounted vertically on a Boyles law stand. The lower end is closed by a one hole rubber stopper through which connection is made with about 4½ ft. of rubber tubing. At the other end of the tubing is an inverted U-shaped glass tube which dips into a calorimeter of other dish. Tube and calorimeter are filled with water. By raising and lowering the calorimeter as a vibrating tuning fork is held over the mouth of the tube the point of greatest resonance is easily obtained. A small shelf on the back of the stand is provided to hold the calorimeter when not in use.

Mr. Miller showed a plank about 8 ft. long and 1 ft. wide reinforced lengthwise on the under side by strips of steel L-shaped in section. One end of the plank rested on a box about 1 ft. high to which it was hinged by a rod which passed through two screw eyes on the upper side of the box and two in the under side of the plank. The other end of the plank rested on a small hydraulic automobile jack, such as can be bought at any accessory store. Six heavy men were persuaded to stand upon the plank and they were lifted by an absurdly small force at the end of the jack handle.

By HOMER W. LESOURD, *Milton Academy.*

A simple analogy to illustrate the principle of convection was shown by Mr. LeSourd. Mercury represented the colder and heavier fluid and water the warmer and lighter one. This experiment was described in the March issue of this journal, page 304.

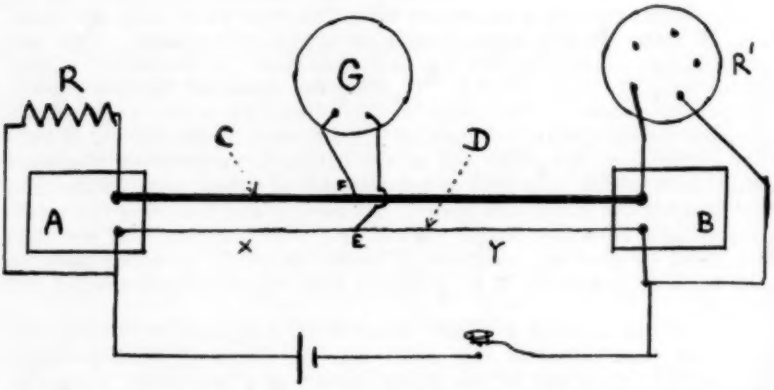
Convection currents may be shown by blowing fumes of ammonium chloride into the air. The apparatus for doing this consists of two small bottles, one containing about a half inch of ammonium hydroxide and the other an equal amount of hydrochloric acid. A two hole stopper is used in each bottle; a glass tube connects the bottles, while a bent glass tube is placed in the other hole of each stopper. All tubes reach just below the stoppers. When a person blows into one tube, white fumes of about the density of air issue from the other tube, and these fumes are carried by air currents. This experiment was described on page 454 of the April issue of this journal.

Color mixing and complementary colors may be demonstrated by means of two lantern slides of glass plates of complementary color. One of these is placed in a lantern and illuminates a white screen. The other is held near the screen so as to cast a black shadow, but when a flash light is held so that its light shines through the slide

onto the screen, two colors and a zone of white light is seen affording an interesting means of testing the pupil's understanding of the principles of color mixing.

By ROY R. HATCH, *Mount Hermon School.*

I have found in common with many others that the ordinary slide wire Wheatstone Bridge needs a good deal of tinkering with in regard to connections, etc., when you want to use it, so I am using the apparatus as diagrammed.




A and B are two blocks of wood with two double binding posts of each. C is a large copper wire or strip of copper, about equal to no. 6 in size, with wire terminal ends soldered to each end. X and Y a piece of German silver wire of any convenient size for the purpose about no. 24 or 26. R is unknown resistance and R′ a calibrated resistance box.

I use a copper wire C four meters long with a clamp at F to connect one side of galvanometer and a sliding contact at E. I find that in actual laboratory practice with these parts of a Wheatstone bridge on the shelves the boys can clamp the blocks on the table and assemble the parts and get much quicker and more accurate results than they can by using the regular form of Wheatstone bridge as furnished by the supply houses.

Mr. Hatch also described an experiment dealing with a locomotive which is printed in the April number of SCHOOL SCIENCE AND MATHEMATICS, page 498.

By THOMAS A. PICKETT, *Mechanic Arts High School, Boston, Mass.*

A DENSITY SET.

A set of metal cylinders for demonstration purposes in teaching density, specific gravity, Archimedes Principle, (and specific heat).

This set consists of a cylinder of aluminum, cylinders of brass, iron, and babbitt equal in volume to the aluminum, and cylinders of the same three metals equal to the aluminum in weight. In addition there is a cylinder of steel which equals the weight of water displaced by the aluminum.

A DEMONSTRATION.

Counterbalance two beakers partly filled with water. Suspend

the aluminum cylinder immersed in the water of one beaker. The pan drops; the "gain in weight" equals the "loss in weight." Now immerse the heavier brass of equal volume in the other beaker. The pans balance, both cylinders displacing equal volumes of water.

This suggests a supplementary method of finding specific gravity:

Weigh the aluminum.

Counter balance a beaker of water on the left platform of the balance.

Immerse the aluminum in this water.

Add weights to the other (right) platform to establish equilibrium.

$$\text{Then S. G.} = \frac{\text{Weight of aluminum}}{\text{"Gain in Weight"}}$$

By W. R. FLETCHER, *North High School, Worcester, Mass.*

1. Coefficient of Cubical Expansion of Liquids Apparatus: The conventional dilatometer (bulb of about 25 cc capacity and stem of very small bore graduated into .01 cc divisions) has some merit but several demerits: it is expensive, is difficult to fill—particularly with a viscous liquid like glycerine, must be constantly refilled in case of volatile liquids, is usable thru a small temperature range, is useless at temperatures above the normal boiling point of the liquid. These disadvantages are obviated in "Fletcher's Cylindrical Dilatometer," made of ordinary glass tubing, about 30 inches long, usually quite uniform in cross sectional area, filled with the selected liquid to within 3 or 4 inches of the end—enough to allow for the expansion thru 100 centigrate degrees, or more, the end of the glass permanently sealed in a blowpipe flame. No boiling results at 100 deg. C when using Sulphuric Ether, Carbon Disulphide, Carbon Tetrachloride, etc.; the coefficient of cubical expansion remains constant at temperatures far above the normal boiling point. Each glycerine tube (e. g.) has the same external diameter; another liquid in tubes of like diameter may have or be given a distinctive color so that no labeling is necessary; thus the complete apparatus may include many liquids and be confined to small tubes of a few different diameters.

Method of Use: Immerse the tube vertically in a container of ice and water; mark the position of the free liquid surface with a section of closely fitting rubber tube; immerse in fluids at 35° C, at 70° C and finally in steam, marking in turn each free surface; thereby several values may be obtained with the same piece of apparatus.

2. Viscosity—Surface Tension—Friction Set: similar to those in No. 1 but of the *same* internal diameter; containing molasses, glycerine, sulphuric acid, brine, carbon disulphide, sulphuric ether, etc., respectively; mounted parallel on the same board; when inverted from a vertical position, the short air column ascends at various velocities.

3. A like set of tube of *different* diameters filled with a copper sulphate solution for better visibility; likewise inverted, the velocity of ascent of the air column varies except in case of those of small diameter, where no motion takes place. No. 2 and 3 afford a chance for speculation, at least.

4. Archimedes Principle: A set of eight bottles filled with nearly equal volumes of non-miscible fluids: (1) gasoline, alcohol, air; (2) water, carbon tetrachloride, air; (3) mercury, water, sulphuric ether, a cork, a steel helix, air; the cork first floated on the ether,

then absorbed enough liquid so that it sank to the water surface; the iron floats on the mercury. Pupils are likely to gain the impression that Archimedes Principle relates to the buoyant effect of liquids upon *solids only*—the fact being that it relates to the buoyant effect of fluids upon solids, fluids, and portions of the fluid itself —e. g. convection currents.

5. Home made sling Psychrometer: Section of brass tubing 12″ long 1″ diam. bottom closed by soldering, top closed with cork, contains water 2″ deep at which height it is bored to receive a wick leading to the wet bulb; the top is pierced by an axis terminated by wooden handles; the thermometers are of the ordinary colored liquid type, bracketed for attachment to a window casing; the brackets pass thru the tube and are soldered thereto. Cost moderate. Functions well.

6. Hydrometers: To demonstrate that buoyant force varies *as* the depth of immersion in the liquid, *as* the cross sectional area, acted upon, and *as* the density of the liquid, i. e.

$$F \propto h, \quad F \propto a, \quad F \propto \delta, \quad \text{when } F = ha\delta.$$

Two pine cylinders, about 18″ long, elongated and stabilized by a brass cylinder of like diameter at the bottom, graduated from the bottom by shallow, circumferential grooves 8 cm apart—the last being at the flotation point—coated with spa varnish so that they may be immersed in almost any liquid without injury, their cross sectional areas being 12.5 and 25 sq cm respectively.

Method of Use: Counterbalance No. 1 on an equal arm lever, the counter-poise resting on the pan of a Dial Dynamometer; when the hydrometer is immersed in water to the first graduation, 100 cc of water are displaced, and 100 gms of buoyant action is shown by the dynamometer; at twice the depth, twice the buoyant force, etc.; the upward force finally equals the weight of the hydrometer and it floats. If No. 2 is substituted, it shows twice the buoyant force as No. 1 at any given depth. Using liquids of various densities verifies the third factor of the formula; mathematical manipulation of the formula will give an expression for pressure, volume-pressure equivalent, weight of a unit column, etc.—each handy in solving problems involving this principle.

7. Parallel Currents Apparatus: Four metal stanchions, 8″ high, set vertically in a board base at the vertices of a quadrangle; sliding T arms at the upper end of each may be clamped so as to bring the mercury cup terminals thereof at desired distances apart; somewhat oblong Al or Cu conductors complete the circuits between the terminals, from and in which they are suspended so that they may have free pendular motion; terminals and connections may be so chosen that the currents pass in the same or in opposite direction in the pendular conductors. A set of T-shaped pendular conductors in conjunction with a mercury trough enables the demonstration to be made in the classical, conventional way. Usable with a horseshoe magnet to illustrate the principle suggested by Fleming's Rule. Two to four amperes for the fraction of a second suffices. More than fulfils the expectations of the inventor.

8. Vernier Measurements: Four *sets* of short sections of brass tubing (right, hollow cylinders), three in each *group* soldered to an oblong, sheet brass base; *set* 10-19 being 2″, 1/2″ outside diameter; 20-29 being 7/4″, 15/16″, 5/16″; 30-39 being 3/2″, 3/4″,

1/4″; 40-49 being 5/4″, 5/8″, 3/8″; the three tubes in each *group* are graded in height and are a trifle longer than the corresponding tube of the *set* having the preceding number; no duplicate heights in the 40 *sets*. When the pupil has measured depth, outside and inside diameter both in metric and English units, he has been exposed, at least, to the opportunity of understanding the vernier principle.

9. Except in the case of the Closed Organ Pipe and the Clarinet, the overtones of woodwind instruments have a frequency of 2, 3, 4, 5, 6, etc. times the frequency of the fundamental; this fact I demonstrated with a Valve Trombone—with the usual mouthpiece for the lower tones and an alto mouthpiece for the higher—since a shorter vibrating membrane requires less tension; the trombone has about 9.5 ft. of tubing; this may be lengthened by depressing the 1st, 2nd, 3rd valves—in that order—which multiplies the 9.5 ft. length by the 1st, 2nd and 3rd power of 1.05946 . . . (being a tempered instrument), then by combinations of these valves the length may be made 4th, 5th, 6th, power of 1.05946 . . . times as long. Instruments of the Trombone type, therefore, have 7 fundamentals on which is built the series of overtones (harmonics) that give the chromatic scale, bridges the gap between the 2nd and 3rd harmonic, etc.

Harmonics having 7, 11, 13, 14, etc. times the fundamental frequency are in tune with the fundamental and with the other overtones but have frequencies between the corresponding pitches of the Pure and Tempered scales, hence must be modulated by the embouchure to be "in tune."

The intervals become closer as the vibration frequency numbers increase, so that the French Horn Artist is able to slur, play chromatics, or diatonics without valves by a combination of embouchure and right hand in the bell.

The advantage of the Trombone and Clarinet to demonstrate harmonics should be evident to anyone who has blown his head off attempting to get three or four overtones on the ordinary organ pipe. With diligent practice and a little wizardry he should get 16 on a Trombone.

10. The harmonics of the Closed Organ Pipe and the Clarinet have 3, 5, 7, 9, 11 . . . . times the frequency of the fundamental; this may account for its more subdued tone; at least one-half the instruments of the modern military band are clarinets—30 of them being required to balance 6 trumpets. My Clarinet has 20 fundamentals so that any one of the higher harmonics may be produced in any one of three or four systems, i. e. "fingerings."

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After lunch some time was spent looking over the new laboratories of the Mechanic Arts High School. We then assembled in the electrical laboratory and Mr. James P. Farnsworth spoke on the course offered the boys in this school. He had assembled a large number of their experiments and demonstrated many of them using not only the lecture table apparatus but also the various machines about the room. This was a very interesting presentation and was enjoyed by the members who could be present to see it.

*(Two addresses delivered at this meeting will be published in the June issue.)*

## JUST A LITTLE GARDEN.

By Mary McIsaac,

*Christopher Gibson School, Dorchester, Mass.*

When our school yard was asphalted a patch near the street was overlooked. The result was an unsightly dried-up spot over which numberless little feet trod for a score of years.

A few years ago my Science Club numbered among its members some of the biggest boys in the graduating class who liked science chiefly because something unforseen might happen during a demonstration. While planning a list of projects for the Club, I thought of the bare tract of land beside the building. I suggested at our meeting that we could have a garden there if we were willing to work hard enough. They boys agreed because any novel experience pleased the majority.

Spades and pickaxes were brought from home and we tackled the yard. The task looked hopeless. To the most inexperienced group it was evident that not even a dandelion could flourish there. Fertilizer was suggested but no one knew what kind. Expert advice was needed. Just here the boys learned how the Federal and State governments assist the farmers by analyzing their soil and advising them as to treatment and crops. So we had our "soil" analyzed. Two kinds of fertilizer were recommended. Fertilizer and seeds cost money. All we had were the Club dues which were being hoarded for an outing in June. One brave soul proposed that the treasury be donated to the cause. With surprising alacrity the others agreed.

While some were cultivating the plot, another group visited Franklin Park to ask the gardeners about early planting. All watched their neighbors' gardens to see if they were going to have flowers. One Saturday a committee went to Boston's largest seed dealer with a request for a list of flowers which would blossom during the school months. I was interested to note that these big boys wanted flowers. There was a love of beauty under the rather hard exteriors. Given the opportunity they were willing to work and spend their money to have flowers of their own.

The seeds fascinated them. Before planting, we examined the seeds and compared them for size, color and shape. They marveled that anything so small could produce a plant. God's greatness was brought vividly to their minds through these tiny messengers.

Interest was contagious. We are an apartment house neighborhood where land is scarce but piazzas are plentiful. Children from other classes began to ask about window boxes and the Club constituted themselves advisors.

We had an illustrated lecture on the New England wild flower and its preservation which was greatly appreciated by the whole school. We had a moving picture showing the growth of flowers and another depicting insect life as it affected plants. The boys began to see the growing things about them. Those who went to camp over the week ends brought back specimens of trees, plants, and "livestock," frogs, garter snakes, turtles, and tadpoles. More of their dues were donated to the purchase of mounting cases which they filled quite artistically and labelled neatly.

I must not forget the bird house which two boys made and which remained untenanted much to the designers' grief. The same boys erected an arbor for the vines to trail over.

We have flowering shrubs in the garden now. The following class set out thirty-two bushes because they wished to leave the school some permanent gift. This group donated their dues to the school as a matter of course.

Each succeeding year the Science Club boys put in five hundred early tulip bulbs among the shrubs. These are used in the Science and Art Departments of the School. Weeding and pruning go on yearly with enthusiasm, but the boys cannot feel the joy of the pioneer group who watched the dirt patch turn into a flower bed.

What did we gain besides a few flowers? Every boy in the plot gained civic pride. He improved his own school property, in many instances he improved his home's surroundings; he learned to respect his neighbor's property because he knew from experience how

much hard work was required to make one flower grow. The boy gained a fundamental store of new facts in an interesting way; his vocabulary was enlarged; he acquired new ideas which could be put into practice during leisure moments. Subscriptions to magazines relating to nature resulted in extensive reading along lines usually considered dull and uninteresting. Proof of this reading was evidenced by the fine donation of news items and pictures for future use.

I wonder if a large garden could accomplish much more?

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## BIOLOGY COLLECTION.

By J. S. JACKSON,

*Bowling Green High School, Bowling Green, Ky.*

In the old school of instruction botany class room instruction was supplemented with the annual arrangement of an herbarium by each student. Since botany, as a separate science, has now been combined with zoology and physiology into biology, the old order of teaching has necessarily changed. The herbarium idea stressed, or even as now used emphasizes one phase of plant study entirely too much. To get away from this exaggeration we have developed a plan in our high school biology classes, which seems to bring excellent results.

Our plan as now used consists in having each student assemble specimen of the four divisions of plant life. The gathering of the material is carried on throughout the study of botany proper. A written report is made of the method of gathering one's collection. Interesting facts noted during field trips are given. This report is more of a descriptive theme than any thing else. A data sheet, naming the specimen, date found, and environment is also compiled. This must be accurate or else full credit is not given for the find. This brings systematic study and teaches laws of environment.

The classification of the specimen is carried out by aid of reference guides, charts, or reference picture, microscopic examination and as a last resort the biology teacher may be consulted. However, the teacher only guides and rarely ever

gives the name of the specimen direct. It is astonishing to note the progress some acquire in making correct analysis and classification.

We have a minimum number of specimen to be found in each division. This number is not made burdensome, neither is it shortened to such a degree as to command no respect. We require three distinct specimen of Algae. The student very early learns to classify the common Algae form, and most often has very little trouble in distinguishing his specimen. However, if an uncommon form is found credit is given even though the specimen may not be accurately named. These Algae are bottled in small vials of formaldehyde and labeled. The department furnishes the formaldehyde and the vials are found by the student or purchased at the local stores. The Fungi include four specimen. Common forms are stressed. Most of these can be preserved dry. The Bryophytes require three distinct mosses. These are preserved dry or may be bottled in formalin. The Pteridophytes furnish much material yet only three distinct specimen are required. These are pressed and dried and used thus. The Spermatophytes are divided; a specimen of Gymnosperm needles and cone are gathered. The Angiosperms offer a wonderful opportunity for study; six specimens of wild flowers with leaves are collected. These are dried and pressed.

Uniform boxes of a desirable color are made by the classes. The cardboard is purchased at the book stores. This making of boxes is desirable rather than using boxes of any size and color. The cost is negligible. The boxes are lined with a cheap grade of cotton, this is then covered with a very thin layer of absorbent cotton. These layers are fastened to a stiff false bottom. Then the specimen are mounted in this box in order of Thallophytes, Bryophytes Pteridophytes, and Spermatophytes. Each specimen having been carefully labeled.

The display is well worth the trouble. The instruction offered repays the student for his labors. Not only does this take him out into God's Great Out of Door's, but it helps to make him realize that biology study does not stop when he completes the year's work but may be continued all his life. The subject becomes life itself and this is what biology must be, to be successful.

## REPORT OF GROUP CONFERENCE ON MODERNIZING OUR SECONDARY SCHOOL SCIENCE.*

By Raymond W. Osborne,

*Francis W. Parker School, Chicago, Ill.*

Science teachers, meeting to discuss ways and means of modernizing science teaching in our high schools agree that extensive reorganization is necessary if the science work of the high school is to be brought into tune with the principles of progressive education as now developed and demonstrated in many elementary schools both public and private. The leaven of progressive education is working upwards from the elementary school, and there are evidences from many directions that it is also working downwards from the colleges. The resultant pressure both from above and below is impinging on the secondary schools and will ultimately force the organization of a new and more modern high school.

The science teachers at the conference were in substantial agreement on the following points:

1. The present differentiation of high school science into a large number of special sciences, Physics, Chemistry, Biology, Domestic Science, etc., is seriously questioned. Fundamental and thorough-going experimentation to develop new and broader groupings of subject matter which will cut across the present differentiated sciences is greatly needed and should be definitely undertaken wherever possible.

2. The science course of the new high school should develop a definite sequence from year to year and from one unit of instruction to the next so that the pupils as they progress through the school will meet problems of increasing difficulty and build continuously on that which has gone before and in relation to that which is to come. A serious criticism of high school science teachers is that they are teachers of "specialties," Physics, Chemistry or Biology and not teachers of science in its broader application to education. This narrow point of view and the limitations of science teachers because of their training as specialists is an important reason why science has not contributed more vitally to the education of adolescent youth.

3. The time allotment for science in the reconstructed

*Summary of a discussion at the conference of the Progressive Education Association, Detroit, Feb. 26, 1931.

high school must be increased if science is to make its full contribution to the development of rational living and thinking and securing on the part of pupils an understanding of science as a way of looking at life and enjoying it, a method of attack for the solution of problems.

To this end several possibilities were proposed by members of the group; that science should be a core subject in the progressive high school extending through both the junior and senior high schools; that the present courses in science might be extended from one year to two years with fewer periods per week and that this would help to secure more continuity of experience and growth on the part of the pupils. Another interesting suggestion was that high school science be reorganized under three heads, Health Science, Civic Science, and Cultural Science. It was pointed out in the criticism of this suggestion that science should enrich the study of civics and of health, but that these divisions alone would not enable science to make its richest contribution to the education of the high school pupil.

4. Is there a body of scientific principles and information which should be brought into the experience of all pupils? A majority of those present seemed to agree that there is such a body of fundamental principles and factual knowledge but the extent and importance of it was called into question by others. This question needs to be settled by accurate scientific investigation. There was however general agreement that it is *essential* to get all pupils to realize that the scientific method is the keenest tool for present and future progress. We need most of all to build up in the pupils the scientific attitude, the questioning yet open mind, and to provide direct experience and training in the use of the scientific method of procedure as a vital part of all the science work done in the high school.

5. The science work of the high school needs to be fully integrated with the science taught in the elementary school, and with the instruction that it is to follow later at the college level.

6. The time is ripe for the high school science teachers to engage in a program of coöperative research and experimentation to the end that science may make its full contribution to the development of a more progressive high school curriculum.

## VELOCITY OF A TRANSVERSE WAVE IN A CORD—A CRITICISM.

By N. F. Smith,

*The Citadel, Charleston, S. C.*

The issue of School Science and Mathematics for June, 1930 (Vol. 30, Page 637), contains an article by Professor F. M. Denton in which the author derives by a new method the well known formula for the velocity of a transverse wave in a stretched cord,—$V=\sqrt{\frac{F}{m}}$. His method is ingenious, but, as it seems to me, the reasoning is so faulty that it should not be allowed to pass unnoticed. His proof is based on Newton's equation, force = mass $\times$ acceleration. He states that the force, in this case, is the tension, F, in the cord; the body moved is "the kink" or wave traveling along the cord; its mass is $m$V, "the rate at which the kink suffers renewal," and the acceleration is V, the "velocity given to this mass in one second." "Whence,

$$F=V(mV)=mV^2"$$

It seems to the writer that the derivation given by Professor Denton is typical of a kind of reasoning which every teacher of physics is anxious to avoid. Newton's law states that when an unbalanced force acts upon a body, the body is given an acceleration in the direction of the force. In the case in question, there is no unbalanced force in the direction of the cord. The only unbalanced force is (for small displacements) at right angles to the cord, and the only acceleration is in this direction. To apply Newton's law to the motion of a "kink" is meaningless, and the fact that the mass of the "kink" is so chosen as to give a correct value for the velocity, in no way justifies the reasoning.

The proof given by Professor Tait, and referred to by Professor Denton, is probably the only satisfactory proof of this important relation which avoids the use of calculus. For a student who has even a very elementary knowledge of calculus, a simple proof may be given if we limit the problem to small displacements which do not change the value of the tension. This is the only case of practical importance. Since this proof seems to be omitted from many texts, even where calculus methods are employed, it may be appropriate to give it here, much as it is given in Lamb's "Dynamical Theory of Sound."

Let the initial direction of the cord coincide with the X-axis. Let $y$ be the displacement of any particle in the cord at any instant. Let the disturbance travel along the cord with a velo-

city, V. The displacement, $y$, is some function of $x$ for any particular instant; or, if $x_1$ is the distance of a particle, $P_1$, from the origin.

$$y = f(x_1)$$

After a time, $t$, the disturbance will have reached a new position, $P_2$, whose distance from $P_1$ is equal to Vt. If we imagine the origin to have moved along with the same velocity, and if $x_2$ represents the distance of $P_2$ from the new origin, then, since the wave-form is unchanged, the displacement of $P_2$ is given by

$$y = f(x_2)$$

But if distances are still measured from the same origin, $x_2 = (x_1 - Vt)$. Hence $y = (x_1 - Vt)$. If we now drop the subscript, we have the general equation of motion of a transverse wave along a cord, where the displacement of any particle is given as a function of $x$ and $t$. If we differentiate this equation twice with respect to $t$, and twice with respect to $x$, we have the standard differential equation of wave-motion:—

$$\frac{d^2y}{dt^2} = V^2 \frac{d^2y}{dx^2}.$$

The force acting on any element of the cord of length $\delta x$ is at right angles to the length of the cord, and is equal to its mass times its acceleration. Calling this force, $p$, $p = m\delta x \frac{d^2y}{dt^2}$ where $m$ is the mass per unit length. This force, $p$, is the difference in the Y−components of the tension, F, acting at the ends of the element, $\delta x$. If $\theta$ is the angle which the tangent to the string makes with the X-axis at one end of the element, $\delta x$, and $\varnothing$ the corresponding angle made by the tangent at the other end, then

$$p = F \sin \theta - F \sin \varnothing = F \cdot \frac{d}{dx}(\sin \theta)\delta x$$

But since the displacements are small,

$$\sin \theta \doteq \tan \theta = \frac{dy}{dx}.$$

$$\therefore p = F\frac{d^2y}{dx^2}\delta x = m\ \delta x \frac{d^2y}{dt^2} \text{ or } \frac{d^2y}{dt^2} = \frac{F}{m} \cdot \frac{d^2y}{dx^2}.$$

Comparing this equation with the differential equation for wave-motion:—

$$\frac{d^2y}{dt^2} = V^2 \frac{d^2y}{dx^2},$$

we see that

$$V^2 = \frac{F}{m} \text{ or } V = \sqrt{\frac{F}{m}}.$$

### A REPLY.

Dear Professor Smith:

I appreciate your courtesy in sending me a copy of your criticism. Since you have failed to follow my reasoning I am afraid many others must have failed. Evidently this little proof is "sufficiently simple to be misunderstood." I think you are wrong when you say "there is no unbalanced force in the direction of the string." At the top corner of the kink there is an unbalanced force and this imparts velocity to the kink. That you have misunderstood the reasoning is evident when you say "the mass of the kink is so chosen as to give a correct value to the velocity." I have chosen no particular value for the size or mass of the kink. I do not say "its mass is $mV$." That is a misquotation. What I say is "the mass constituting the kink suffers continual renewal at the rate $mV$ grams per second." This is true no matter what the size or shape of the kink. You say, "To apply Newton's law to the motion of a kink is meaningless." Far from being meaningless it is in fact very instructive. For instance, the moving kink has kinetic energy ($\frac{1}{2}$ MV$^2$) due to its motion, and potential energy due to its size and shape. It has momentum (MV) and it has rate of change momentum (=F). It is an interesting example of a system in which there is always a rate of change yet never a change. The rate of change of momentum belongs to a system (the "kink") whose identity continuously changes. (I think F=MA ought to be called not a *law* but a definition. Actually it is a "circular" definition, for it has to define both F and M, neither of which is a "real" quantity.)

The proof is, I believe, quite sound, but it is apt to be misunderstood unless read very thoughtfully.

Sincerely yours,

F. M. DENTON.

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### CONCERNING THE SPEED OF A TRANSVERSE WAVE IN A CORD—A DISCUSSION BY THE EDITOR FOR RESEARCH IN PHYSICS.

It is hardly necessary to say that any derivation that is apt to be misunderstood by an experienced teacher of physics is of doubtful value for the beginner, even if the derivation is correct. I have read Professor Smith's criticism

of Professor Denton's article and also the reply made by Professor Denton; it is my opinion that Professor Smith's criticism is entirely justified.

Professor Smith is correct in saying that for small displacements the only unbalanced force is at right angles to the string and that the only acceleration is in this direction. He might make this statement still more emphatic by adding that the only time rate of change of momentum is also in this transverse direction. In deriving the expression $V=\sqrt{F/m}$ from the wave equation and Newton's second law, as Professor Smith has done, one assumes that the angle $\phi$ is small; this is equivalent to the assumption that there is no unbalanced force in the longitudinal direction. Even for large displacements, the longitudinal component of the force on any element on the string dx is equal to $\frac{\partial F}{\partial x}dx$, and not to the tension F.

It is true that the disturbance travels with a speed V along the string and that the mass affected is increased by an amount mV per second, but this mass does not receive a velocity V and it is not acted upon by a force F. Energy is transferred along the string and it is this energy which travels with the speed V.

In his original paper, Professor Denton says that ". . . the mass constituting the kink suffers continual renewal at the rate mV grams per second. Thus the mass to which velocity V is imparted in each second is mV, and in the formula F=AM we have A=V and M=mV, whence $F=V(mV)=mV^2$ and $V=\sqrt{F/m.}$" But if M is the time rate of change of mass then MA is not force but force divided by time. Now force is best defined by means of the equation $F=\frac{dp}{dt}$, where p is the momentum; since $p=MV$, one may restate this definition in the form $F=\frac{dM}{dt}V+M\frac{dV}{dt}$. If M does not vary with the time, this reduces to F=MA; if M does vary with the time and A=0, it reduces to $F=\frac{dM}{dt}V$. Professor Denton states that he employs the equation F=MA but also says that "the kink moves with uniform velocity V along the string toward B. We may regard the force F as causing this motion," a statement

which implies that he intended to use $F=\frac{dM}{dt}V$.

The formula $F=\frac{dM}{dt}V$ is useful for solving problems in ordinary mechanics of the following type: *a train moving horizontally with a constant velocity V acquires mass at the rate of m grams per second from, say, a vertically falling rain. Find the force, in addition to that necessary to overcome friction, required to pull the train with constant velocity V.* It is not necessary to use calculus in the solution, since $\frac{dM}{dt}=\frac{M_2-M_1}{t_2-t_1}=\text{constant}$.

I agree with Professor Denton in his assertion that F=MA is a definition and not a law. It is not a "circular" definition, however; to say this would be to say that it is neither a definition nor a law. If F=MA "has to define both F and M," it is then a meaningless and useless equation so far as the purposes of physics are concerned. As has long ago been pointed out, however, Newton's third law provides a means for making a direct measurement of mass and hence provides a definition of the concept. I am not entirely convinced that the definition of mass based on the third law is entirely satisfactory for the purposes of relativity mechanics although I am inclined to believe that it is.

## PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
*Illinois State Normal University.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor* should have the author's name introducing the problem or solution *as on the following pages.*

*The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.*

### LATE SOLUTIONS.

**1156.** *Viola Lyon Bently, Los Angeles, Calif.*

**1143.** *Edward M. Tucker, Georgetown, Mass.*

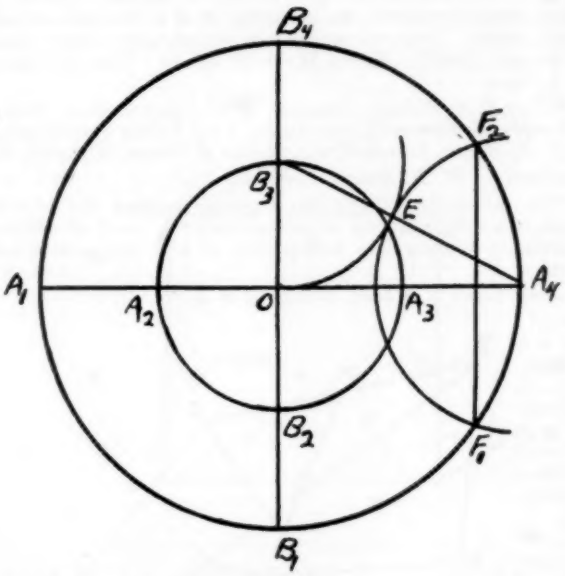
**1143.** *Proposed by the Editor.*

Taken from an article in August-September, American Mathematical Monthly, written by Gladys Gibbens, University of Minnesota. In this article is an analytical proof of the following construction of a regular pentagon.

Draw a circle with $OA_2$ as radius, and a concentric circle whose radius is twice as large. Draw the horizontal and vertical diameters as indicated.

Draw $B_2A_4$, meeting a circle with $B_3$ as center and radius equal to $OB_3$ at E. Draw a circle with $A_4$ as center and radius $A_4E$, meeting the large circle at $F_1$ and $F_2$. Then $F_1F_2$ is a side of a regular pentagon inscribed in the circle $A_1B_4A_4B_1$.

Required (a) a proof suitable for High School pupils (b) a synthetic Proof.




*Solved by W. E. Buker, Leetsdale, Pa.*

Let $F_2F_1$ and $A_1A_4$ intersect at M. Draw $A_1F_2$ and $F_2A_4$.

Let $OA_4 = R$. Then $OB_3 = R/2$; $B_3B_4 = R\sqrt{5}/2$; and

$$EA_4 = F_2A_4 = (\sqrt{5}-1)R/2.$$

We know $F_2A_4$ and wish to find $F_2F_1$. That is, we know the side of a regular inscribed polygon, and desire to derive an expression for the side of a regular inscribed polygon of half the number of sides. In most elementary Plane Geometries the converse of this problem is used in finding a numerical approximation to the value of pi.

Now $A_1A_4F_2$ is a right triangle and $F_2M$ is $\perp$ to $A_1A_4$. Then triangles $A_1A_4F_2$ and $A_1F_2M$ are similar. By the Pythagorean Theorem,

$A_1F_2 = (R/2)\sqrt{10+2\sqrt{5}}$.

Also $A_1A_4 : F_2A_4 = A_1F_2 : F_2M$, or

$2R : (R/2)(\sqrt{5}-1) = (R/2)\sqrt{10+2\sqrt{5}} : F_2M$.

Hence $F_2M = (R/4)\sqrt{10-2\sqrt{5}}$, and $F_1F_2 = (R/2)\sqrt{10-2\sqrt{5}}$, which is the well known expression for the side of a regular pentagon in terms of the radius of the circumscribed circle.

## SOLUTIONS OF PROBLEMS.

**1157.** *Proposed by W. E. Buker, Leetsdale, Pa.*

The vertices of a triangle are at $(X_1, Y_1)$, $(X_2, Y_2)$ and $(X_3, Y_3)$. Find the equation of the envelope of the Simson lines of the given triangle.

**Editor.** No solutions were received.

**1158.** *Proposed by Daniel Kreth, Wellman, Iowa.*

The amount of $1,000 at compound interest for a stated time and

stated rate is \$1,610.51. The amount of the same sum at the same rate for the same time at simple interest is \$1,500. Required the rate and the time.

*Solved by B. M. Lindemuth, Defiance, Ohio.*

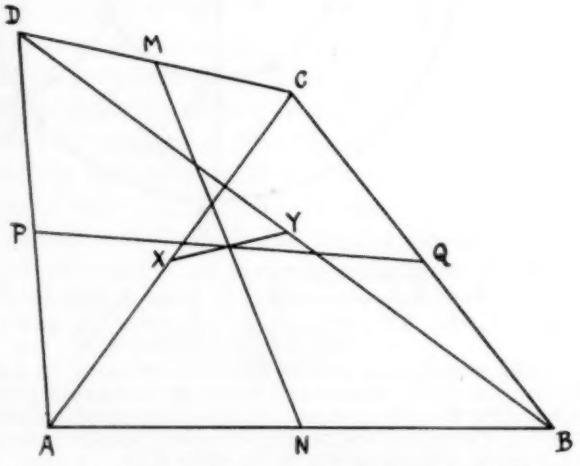
Let N = the time and R = the rate. $1000RN = 1500 - 1000 = 500$. $RN = 1/2$, or $R = 1/2N$. $A = P(1+R)^N$ is the formula for compound interest. $1000(1+R)^N = 1610.51$ or $(1+R)^N = 1.61051$. From $N\log(1+1/2N) = \log(1.61051) = .20697$, substituting $N = 4$, we get .20460; using $N = 8$, we get .21056. Thus we see that $N = 4$ is nearer correct than $N = 8$. For $N = 5$, we get .20697. Hence $R = 1/10$ or .10. The rate is 10% and the time is 5 years.

Also solved by *E. A. Holister, Pontiac, Mich.; Bert Norbert, Trinity H. S., Chicago, Ill.; Hazell Fliess, Clifton Forge, Va.; Sudler Bamberger, Harrisburg, Pa.; W. E. Buker, Leetsdale, Pa.; Louis R. Chase, Newport, R. I.*

**1159.** *Proposed by W. E. Buker, Leetsdale, Pa.*

*Prove:* The mid-point of the line-segment joining the mid-points of the diagonals of a quadrilateral coincides with the point of intersection of the line-segments joining the mid-points of the opposite sides of the quadrilateral.

**I.** *Solved by Louis R. Chase, Newport, R. I.*




It is well known, and easy to show, that the mid-points of the sides of any quadrilateral are the vertices of a parallelogram. M, X, N, and Y are the mid-points of the sides of the quadrilateral ABDC. M, P, N, and Q are the mid-points of the sides of the quadrilateral ABCD. Therefore, MN and XY are the diagonals of a parallelogram, and bisect each other. The same thing is true of MN and PQ. Hence the mid-point of PQ coincides with the mid-points of MN and XY.

**II.** *Solved by Joseph L. Stearn, Brooklyn, N. Y.*

Consider a quadrilateral with vertices at (O, $c$), ($a$, O), (O, $-d$), and ($-b$, O) respectively. Let E be the mid-point of $P_3P_4$; and F the mid-point of $P_1P_2$; C the mid-point of $P_1P_4$; D the mid-point of $P_2P_3$. The equation of EF is

$$\frac{2x-a}{a+b} = \frac{2y-c}{c+d}.$$

The equation of CD is

$$\frac{2x+b}{-(a+b)} = \frac{2y-c}{c+d}.$$

Solving these two equations, we get $x = \frac{a-b}{4}$ and $y = \frac{c-d}{4}$.

These are the coordinates of the third point mentioned.

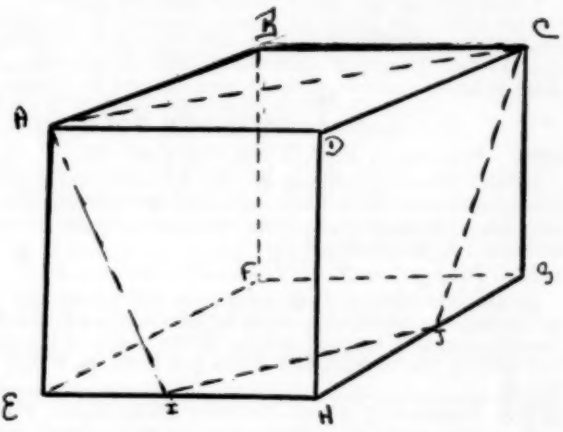
Also solved by *B. M. Lindemuth, Defiance, Ohio; Bert Norbert, Chicago, Ill.; Martha Liddell, Bartlesville, Okla.; R. T. McGregor, Elk Grove, Calif.; W. E. Baltzer, Battle Creek, Mich.; E. A. Hollister, Pontiac, Mich.;* and *Armand H. Lundquist, Richfield, Idaho.*

**1160.** *Proposed by Guy C. Lentini, Boston, Mass.*

Indicate how you would pass a plane through a cube in order that an isosceles trapezoid may be obtained whose bases are in the ratio of 2 to 1.

*Solved by Marge Joseph, Milwaukee, Wis.*

If AB=1, then AC=$\sqrt{2}$. I is the midpoint of EH; J is the midpoint of GH. Then IJ=$\sqrt{2}/2$. Therefore, the isosceles trapezoid ACJI is the required one.




**Editor:** There are many ways of making this type of construction.

Also solved by *W. E. Buker, Leetsdale, Pa.; Bert Norbert, Chicago, Ill.; Hazell E. Fliess, Clifton Forge, Va.; W. E. Baltzer, Battle Creek, Mich.; Louis R. Chase, Newport, R. I.; E. A. Hollister, Pontiac, Mich.;* and *Edward M. Tucker, Georgetown, Mass.*

**1161.** *Proposed by Ellsworth Gosnell, Leetsdale, Pa.*

*Prove:* In any polyhedron having the same number of faces at each vertex, the number of vertices times the number of faces at each vertex equals twice the number of edges.

*Solved by Louis R. Chase, Newport, R. I.*

The word "edges" may be substituted for the word "faces" in the above statement, there being the same number of each at any vertex. In multiplying the number of edges at each vertex by the number of vertices, the edges will be counted twice, since each edge runs to two vertices.

**1162.** *Proposed by H. L. Olsson, Elmhurst, Ill.*

Three men, A, B, and C cut down a tree. After trimming it, they have a log 40 ft. long. The diameter at the base is 4 ft. and at the top or small end the diameter is 2 feet. Into what lengths must they saw the log so that each gets the same amount of lumber?

*Solved by E. A. Hollister, Pontiac, Mich.*

The log is a frustum whose volume is

$$\frac{\text{pi H}}{3}(R^2_1+R_1R_2+R^2_2)=\frac{280\text{ pi}}{3}\text{ cu. ft.}$$

Each man should get (280 pi)/9 cu. ft.

Cut from the large end a length X whose upper radius is R.

Hence, $(280\text{ pi})/9=\frac{\text{pi X}}{3}(4+2R+R^2)$, in which $R=(80-X)/40$.

The equation reduces to

$$3X^3-720X^2+57600X-448000=0.$$

By Horner's method, $X=8.69$ ft.

A similar cut from the small end of length Y whose radius at larger end is N has a volume

$$(280\,\text{pi})/9=\frac{\text{pi}\,Y}{3}(1+N+N^2), \text{ where } N=(40+Y)/40.$$

This equation reduces to

$$3Y^3+360Y^2+14400Y-448000=0.$$

By Horner's method, $Y=19.75$ ft.

This leaves for the center piece a length of 11.56 ft.

Also solved by *Louis R. Chase, Newport, R. I.; B. M. Lindemuth, Defiance, Ohio; W. E. Buker, Leetsdale, Pa.; R. T. McGregor, Elk Grove, Pa.; Bert Norton, Trinity H. S., Chicago, Ill.; R. L. Calvin, Youngstown, Ohio; Adsum, Lewis Institute, Chicago;* and *Edward M. Tucker, Georgetown, Mass.*

## PROBLEMS FOR SOLUTION.

**1175.** *Proposed by E. B. Escott, Oak Park, Ill.*

In the binomial expansion $(X+1)^2=X^2+2X+1$, I notice that there are three coefficients in arithmetical progression, that is, 2, 1, 0. Are there any other binomial expansions where three consecutive coefficients are in arithmetical progression?

**1176.** *Proposed by B. M. Lindemuth, Defiance, Ohio.*

In attempting to cross a stream at right angles to the current, a man finds that the best he can do is to land 3 miles down stream from a point directly opposite starting point. If the width of the stream is 4 miles and the rate of the current is 5 miles per hour, how fast can he row in still water?

**1177.** *Proposed by Albert Whitman, Philadelphia, Pa.*

Find a number N so that the sum of the digits of its square gives $X^2$, and the sum of the digits of its cube gives $X^3$.

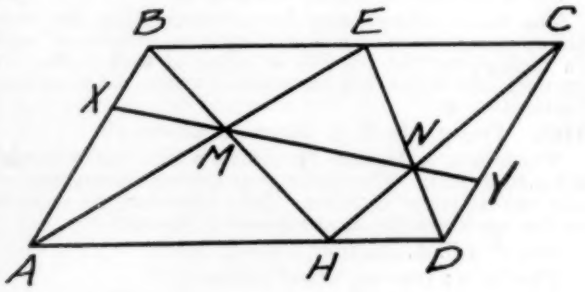
**1178.** *Proposed by H. R. Scheufler, Culver, Indiana.*

Inscribe an equilateral triangle within an angle with one vertex at a given point within the angle.

**1179.** *Proposed by R. T. McGregor, Elk Grove, Calif.*

If the vertices of an equilateral triangle inscribed in a circle are joined to any point on the circumference, show that one join equals the sum of the other two joins.

**1180.** *Proposed by A. Struyk, Paterson, N. J.*




ABCD is a parallelogram. E is any point on BC; H is any point on AD. AE, BH intersect at M; DE, CH intersect at N. The line through M and N meets AB at X, and CD at Y. *Prove:* $AX=CY$.

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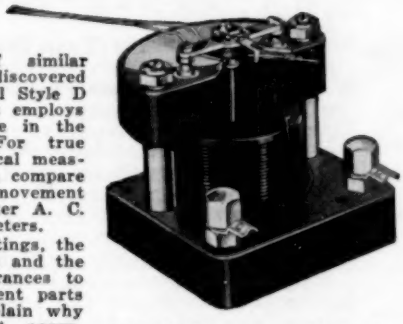

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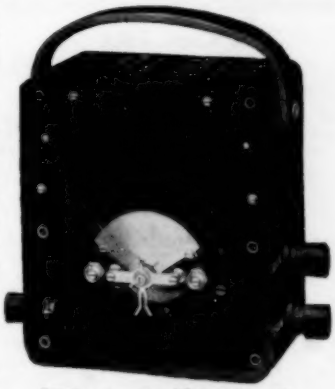

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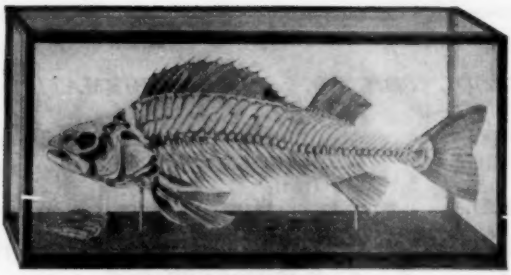

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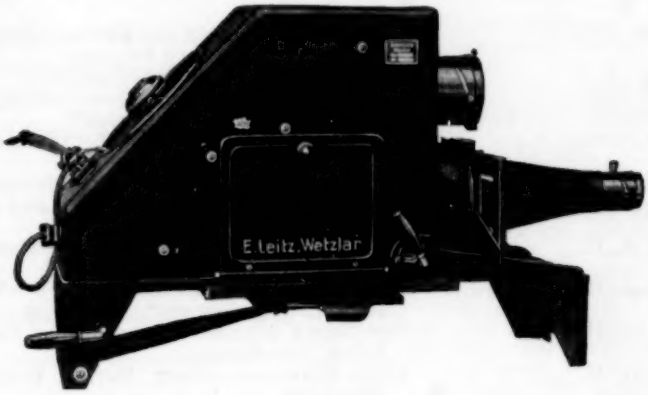


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| Young, S. Hall | ALASKA DAYS WITH JOHN MUIR—Mountain and glacier climbing |

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## BOOKS RECEIVED.

Kostychev's Chemical Plant Physiology written and revised by Dr. S. Kostychev, Member of the Russian Academy of Science, Professor in the University of Leningrad and translated and edited by Charles J. Lyon, Assistant Professor of Botany at Dartmouth College. Portrait and 45 illustrations. Cloth. Pages xv+497. 15x23 cm. 1931. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $6.00.

The Volterra Integral Equation of Second Hand by Harold Thayer Davis, Associate Professor of Mathematics in Indiana University. Cloth. 76 pages. 14.5x22.5 cm. 1930. Indiana University Book Store, Bloomington, Indiana. Price paper cover $1.00 and Cloth $1.25.

Atlas Céleste par E. Delporte, Astronomr à l'Observatoire royal de Belgique. Cloth. 54 pages. 21x27.5 cm. 1930. Macmillan Company, 60 Fifth Avenue, New York.

A Brief Course in Physics by Charles H. Lake, First Assistant Superintendent of Schools, Cleveland, Ohio and George P. Unseld, Head of the Department of Physics, The West High School, Salt Lake City, Utah. Cloth. Pages vi+468. 13x19.5 cm. 1931. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.68.

College Algebra by Lloyd L. Smail, Professor of Mathematics, Lehigh University. First Edition. Cloth. Pages xv+450. 13.5x20.5 cm. 1931. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York, N. Y. Price $2.50.

Mathematics for Junior High Schools, Book One for Seventh Grade and Book Two for Eighth Grade by Leo J. Brueckner, Professor of Elementary Education, University of Minnesota; C. J. Anderson, Dean of the School of Education, University of Wisconsin and G. O. Banting, Superintendent of Schools, Waukesha, Wisconsin. Pages xiv+370. 13x19 cm. 1931. The John C. Winston Company, 1006-1016 Arch Street, Philadelphia, Pa. Price Books I and II, $1.00.

Mathematics for Junior High School, Book Three for Grade Nine by Leo J. Brueckner, Professor of Elementary Education, University of Minnesota; Laura Farnam, Bryant Junior High School, Minneapolis, Minnesota and Edith Woolsey, Sanford Junior High School, Minneapolis, Minnesota. Pages xiv+456. 13x19 cm. 1931. The John C. Winston Company, 1006-1016 Arch Street, Philadelphia, Pa. Price $1.28.

Mathematical Tables and Formulas compiled by Robert D. Carmichael and Edwin R. Smith. Cloth. Pages viii+269. 15x23 cm. 1931. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.00.

Smith's Introductory College Chemistry by James Kendall, Professor of Chemistry in the University of Edinburgh. Cloth. Pages

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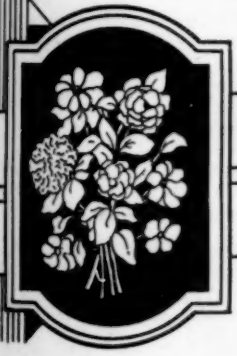

# BOTANICAL PRODUCTS

xii+555. 13x20 cm. 1931. The Century Company, 353 Fourth Ave., New York, N. Y. Price $3.25.

Modern Chemistry by Charles E. Dull, Head of Science Department, West Side High School and Supervisor of Science for the Junior and Senior High Schools, Newark, New Jersey. Cloth. Pages xii+776. 12x18.5 cm. 1931. Henry Holt and Company, 1 Park Avenue, New York City.

Structure Symbols of Organic Compounds by Ingo W. D. Hackh, of San Francisco. Author of "A Chemical Dictionary" and "Chemical Reactions and Their Equations." Cloth. Pages viii+139. 13x20 cm. 1931. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

Alte Und Neue Mathematische Spiele by Dr. Gerhard Kowalewski, O. Ö. Professor Der Reinen Mathematik an Der Technischen Hochschule Zu Dresden. Cloth. Pages vi+145. 13x20.5 cm. 1930. Verlag Und Druck Von B. G. Teuber, Leipzig.

## PAMPHLETS RECEIVED.

A Study of Unfounded Beliefs Among High-School Seniors by Gerhard E. Lundeen and Otis W. Caldwell, Institute of School Experimentation, Teachers College, Columbia University. 19 pages. 15x23 cm. 1930. Reprint from November 1930 Journal of Educational Research.

The History of Teacher Placement prepared by The National Association of Teachers' Agencies, 330-331 Chamber of Commerce Building, Columbus, Ohio. 32 pages. 16x21 cm. 1931.

The Training of Science Teachers for Secondary Schools by Hanor A. Webb, Professor of the Teaching of Chemistry, George Peabody College for Teachers. 8 pages. 16x23 cm. 1930. Reprint from Science Education, November 1930.

A Method of Determining the Relationship Between Types of Farming, Content in Vocational Agriculture and the Technical Training of Teachers of Agriculture by Ralph Hicks Woods. 111 pages 15x22 cm. September 1930, Volume III, No. I. Bulletin of the Bureau of School Service, College of Education, University of Kentucky, Lexington, Kentucky.

Annual Report of the General Education Board 1929-1930. Pages xv+75. 13.5x20.5 cm. General Education Board, 61 Broadway, New York City.

## BOOK REVIEWS.

*Plane Trigonometry, with Tables, by William Wilder Burton, Ph. B., A. M., Assistant Professor of Mathematics, Clemenson College, Clemenson College, S. C.* Pages x+125+vii+93. 14x21 cm. 1931. Thomas Y. Crowell Company, 393 Fourth Avenue, New York. Price $2.50.

This Trigonometry has the following features.

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J. M. Kinney.

*Solid Geometry, by Joseph P. Mc Cormack, Head of the Department of Mathematics in the Theodore Roosevelt High School, New York City.* Pages viii+168. 12.5x19 cm. 1931. D. Appleton and Company, 35 West 32nd Street, New York. Price $1.24.

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*Mathematics for Junior High Schools, by Leo J. Brueckner, Professor of Elementary Education, University of Minnesota, C. J. Anderson, Dean of the School of Education, University of Wisconsin, and G. O. Banting, Superintendent of Schools, Waukesha, Wisconsin.* Cloth. Book One pages xiv+370, Book Two pages xiv+370, Book Three pages xiv+456. John C. Winston Company, Chicago.

These books represent a well organized series of mathematics texts for use in Junior High Schools. The material is presented in such a way that the pupil is led to see for himself the interrelation of the various branches of mathematics being studied. The books contain many live applications to every day life and seem to be free of dead timber. At the end of many of the chapters, supplementary materials are included for brighter children. Some of the special features of the series are as follows:

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The books are attractively bound and contain many fine illustrations. They show careful editorial preparation.

C. A. Stone.

*Geometry Workbook, by H. B. Kingsbury, Chairman, Department of Mathematics, West Division High School, Milwaukee, Wisconsin, and R. R. Wallace, Instructor in Mathematics, Calumet High School, Chicago, Illinois.* The Bruce Publishing Co., Milwaukee, Wis., 1930.

This workbook contains 78 practice tests and 10 review tests consisting of material that may be used for supplementary drill and test purposes. The book can be used with any geometry text. Provision is made for recording results on each test, and on the inside of the front cover there appears a record summary which may be used in checking pupil progress. The book is attractive and should find favor with teachers in need of such a teaching device.

C A. Stone.

*Mathematics, by Fred Englehardt, Professor of Education in the University of Minnesota, and Mary L. Edwards of the Department of Mathematics, Roosevelt Junior-Senior High School, Minneapolis.* Seventh year, pages xvi+232; Eighth year, pages xii+273; Ninth year—Algebra, pages xii+418. D. Appleton and Co., Brooklyn.

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George E. Hawkins.

*The Carbon Compounds, A Text-Book of Organic Chemistry, by C. W. Porter, Professor of Chemistry in the University of California. Second Revised Edition.* pp. ix+469. 16.4x23x2.5 cm. With a few illustrations and tables. Cloth. 1931. Ginn & Co.

This revision has been made in order to bring the text in line with recent developments in organic chemistry. "Nearly every section of the book has been improved either by the addition of new material or by a better organization of the original subject matter." The structure of sucrose has been revised, thyroxine and other amino acids have been discussed and more recent treatments of protein salt formation have been given. Many references to current literature have been added. Just to sample the spirit and method of the text the reviewer made a little study of the presentation of hydroxy acids with its treatment of the several tartaric acids and found it admirable.

F. B. W.

*Algebra Charts by Edgar Dehn, Columbia University. Columbia Press, 509 Fifth Ave., New York. Set of Six Charts, $1.00; single charts with directions, 15 cents, may be obtained in the bookstores.*

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We have a science club which carries on a series of industrial trips, eight or ten a year, alternating with home meetings at which the members present papers and experiments. The stimulus for this club work comes largely from the members of the club themselves. Many projects are now under way by the club members. They include, at present, testing various sorts of crystals in a simple crystal radio receiving set, making charts for class room use, preparation of copper sulphate from scrap copper, making military gin cotton, preparing a dye from anilin produced from benzehe, and recovery of laboratory by-products such as $Fe\ So_4$ from the $H_2S$ generator. Electric furnaces or other high temperature furnaces always held great attraction, and we usually have two or three made a year with varying degrees of success.

The writer feels that the inspiration gained from frequent attendance at meetings of professional organizations has been worth while.

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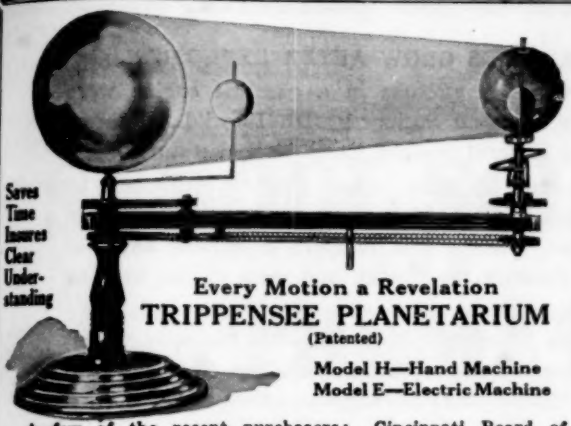
The Rocky Mountain Teachers' Agency, 410 U. S. Natl. Bank Bldg., Denver, Colo., has just sent us a little booklet entitled "How to Apply for a School and Secure Promotion, etc." This booklet contains much valuable information to teachers making applications for positions. It is given free to members of the agency.



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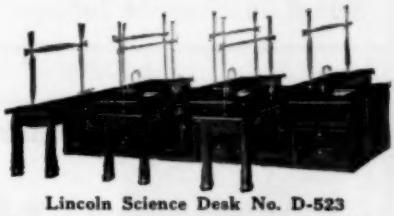

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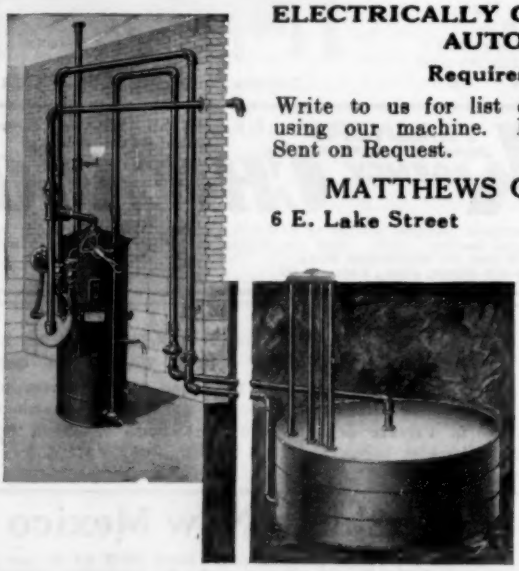

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